THE

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CONTENTS:

	PAGE
Twenty-five Years of Mechanical Progress	387
Is our Coal Industry in Danger?	388
The British Association:—	
Address to the Mathematical and Physical Section ...	389
Electric Glow Lamp Tests (*illustrated*)	391
Liverpool Overhead Railway (*illustrated*)	397
On a Complete Apparatus for the Study of the Properties of Electric Waves (*illustrated*)	400
Incandescent Lamp Tests	401
Correspondence:—Oh! Swallow, Swallow! (*illustrated*) ...	402
Lamp Earnings	402
Dynamo Patents	403
Electrolysed Sea Water	403
Workhouse Lighting	403
Lock Armour for Electric Light Cables	403
The Submarine Telegraph Memorial	403
Business Notices, &c....	403
Electric Lighting Notes	404
Electric Traction and Motive Power Notes	405
Telegraph and Telephone Notes	405
Contracts Open and Closed	406
Notes	406
City Notes	410
Traffic Receipts	410
Share List of Electrical Companies	411
A Completed Chapter in the History of the Atomic Theory (*concluded*)	412
How to Save Money on Feeders (*illustrated*)	414
The Brush Company's New Alternator (*illustrated*)	415
X Radiation at the British Association	417
New Patents	418

THE

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TWENTY-FIVE YEARS OF MECHANICAL PROGRESS.

AN address before the Mechanical Science Section of the British Association must be a very trying thing to deliver, or at least to compose. It is impossible that there can be so much of novelty since the previous year to afford material for an address of any length. Sir Douglas Fox was therefore wise in taking as his text the progress of mechanical engineering since last the Association met in Liverpool, rather over a quarter of a century ago. The past 25 years have witnessed a remarkable expansion, quite apart from the birth and growth of the now important branch of electrical engineering. An addition of nearly 50 per cent. to the railway mileage of the country until England and Wales now head the list of mileage ratio to area, and a doubling of the invested capital, show what steady progress has been made. An addition of 50 per cent. to the population of Liverpool and Birkenhead tells the same story. All these figures, and other information contained in the address, are mere matters of statistics; but they were well presented, and Sir Douglas Fox's address is fully equal to any we remember. He was particularly happy in drawing attention to a direction in which progress has not been made—that of electrical railways. Only a few miles of line have yet been made in this country. Yet in America, with less than double our population, there are over 12,000 miles of electrical railway or tramway. In Brooklyn alone, one company works 260 miles of overhead trolley lines. It is to be urged that progress in America has been assisted by the greatness of the distances and the poverty of other means of communication, but it is as well not to urge these points too strenuously, but rather to inquire if there are not many more opportunities here than are suspected. What has been done here in the shape of the Liverpool Overhead Railway has no superior. It is not that we cannot build and successfully work electrical railways.

The cost of a mile of conduit tramway in America is set down as £7,580, and the operating cost of 4 miles of double track for 24 hours per day at 2½ minutes headway, is given at 4·55d. per train mile of one motor car and one trailer. Sir Douglas looks on electricity as best lending itself to the demands of a growing district of any form of power.

The motor vehicle for common roads is held up as a field for mechanical ingenuity. Costing no more than a horse and carriage, the fodder cost for a horse during its 20 miles per day is 2d. per mile as against ½d. for the motor car of 2½ horse-power.

The able lecturer advocates the metrical system very strongly. He even looks upon it as essential in the getting back of trade that he avers to have been lost. He does not point out that some of the trade we are said to have lost has been lost to Americans who use our own system. The unfortunate part of the metric system is its decimal division. To say that its use is universal abroad is not correct. We have ourselves heard the good people of Amsterdam, who are nothing if not near, order a quarter of half a kilogramme of tea, showing, in the first place, that the kilogramme is too large a unit for ordinary purposes, and so the people use the

half kilo. as their unit, and in the second place they ask for halves and quarters of the convenient unit. The quarter of a half kilogram is a full quarter of a pound. Why was not a hectogram of tea purchased? Simply because the common people of foreign countries are not superior to our own common crowd, and can only conveniently count in halves. The decimal base is a mistake. It cannot be used mentally, and the metrical system is founded badly to begin with, and even if universally adopted it will never be a good instrument to work with. We should like to ask Sir Douglas Fox if he or his assistants cube up earthwork on a decimal or a duodecimal system, or whether if given any quantity to multiply by 3·125 he would himself perform four operations of multiplication and one of addition, or simply multiply by three, divide by eight, and add the two results.

The one great class to be benefited by the rigid enforcement of the metrical system would be the wranglers who have not the possession of financial ability. They could help out the poor housewives on Saturday night in estimating the true value of 3·37 kilos. of a grocery at 73·25 centimes.

The use of the system by physicists and chemists is absolutely no argument in its favour. The one argument that can be urged is that of internationality. We can understand its use in anthropometric measurement, but we believe eventually the universal system will be one with a duodecimal base.

In the course of the address many matters were lightly and briefly touched up which concern the mechanical engineer, and one is forced to conclude that most, if not all, of the great advances made by civil engineers, using the term in the narrow sense, are entirely due to the possibilities born of mechanical progress. Tunnelling, ventilation, electrical railways, canal and dock making, all owe their present status to advances made along mechanical lines; and bridge building is more than ever a question of machinery. Indeed, in every sense, the mechanical engineer is the man.

IS OUR COAL INDUSTRY IN DANGER?

The *Mining Journal* of the 19th inst., announces, with great regret, that one of the large collieries in East Durham is to be laid in. This stoppage will throw out of employment about 2,000 hands, and will seriously affect the entire population of the village of Haswell, amounting to about 8,000 souls. The mine has been producing some 400,000 tons of coal per annum, but the shutting down has been necessitated because of unprofitable working. The company has been not only unable to pay the shareholders any dividends, but has been losing money, and latterly very heavily. Another colliery—the Rainton—was stopped for a similar reason, and it seems exceedingly unlikely, says the organ of the mining industry, that any other company will come forward to take up the leases. Lord Durham also disposed of his Durham collieries because they were unprofitable.

We agree with our contemporary that the stoppage of these collieries is a matter for national regret, and it is therefore time that electrical men turned their attention more in this direction, bringing electricity to the rescue, and by the aid of electric haulage, coal cutting, pumping, &c., lead to more economical working. There are, of course, says our contemporary, two factors in this disastrous occurrence to be considered—namely, the price at which the coal can be got from the Haswell mine, and that at which it can be sold in the world's market. The first point more directly concerns electrical engineers, and, we believe, the circumstances in this particular mine are such that electricity used for the transmission of power is just what is required to mend matters. The mine is an old one, having been worked for some 60 years, and in consequence, the working face is a long way "inbye," or in other words, the coal that is left is a long way from the shaft, which must necessarily mean expense in various ways, and particularly so in regard to haulage.

Our contemporary adds:—"It may also be taken for granted that in an old colliery the general arrangements are not suited to modern machinery and modern methods of economical working. Nor is there at the present moment any inducement to spend large sums on the equipment of such a colliery; if it cannot pay dividends on the capital already invested, there is no encouragement towards putting additional capital into it." With the first portion of this argument we are in cordial agreement, for it is a question whether the motive power and machine tools in many operative centres, besides mining districts, should not be entirely removed and modern plant substituted, a course of procedure which, in many industries, might be advantageously carried out periodically; but with the logic, or want of it, of the last part we have no patience.

The very reason it cannot pay on the capital already invested appears to be due to the enormous expenses entailed by the crude methods of operating; add a trifling percentage to that capital for the purpose of installing electrical haulage and coal-cutting plant, and the present loss should be readily turned into a profit, and good dividends earned on the slightly increased capital.

Electrical power transmitted over the distances required in mining work is far more economical than steam power and compressed air, and gives better results in regard to efficiency. In our article last week on "Electricity down a Coal Mine," the working conditions of which we personally investigated, we stated that in the colliery there described the capital required for equipping the mine with electrical plant was only one-half that for compressed air, which only gave 30 per cent. efficiency, while the electrical plant gave 65 per cent. These facts point to an immense field for the application of electricity in coal mining, and we think that large colliery owners, whose pits are no longer profitable under the conditions of days gone by, would do well to consider thoroughly the advantages of electricity, as properly applied, before they close down mines which, under present auspices, are considered to be financial failures. Electricity is just suited for such work, as has been recently exemplified in both home and foreign collieries. It is not only suited for use for motive power purposes, but it is also employed economically for lighting. Only this week, an instance has been brought to our notice where an electric lighting plant laid down in a Raven Hill mine reduced the lighting bill very considerably. And these little economies are worth considering. There is, however, one factor in the coal mining industry with which even electrical machinery is powerless to cope, and that is with the perversity of human nature. This perversity is recognised by the *Mining Journal*, whose concluding remarks we quote:—

"With regard, however, to the second item we mentioned—the low selling price—we cannot but think that for this the miners have themselves to blame to a great extent. The world's output of coal is growing rapidly, and Great Britain's production is no longer, as it used to be, the essential feature of that increase. Our continual and protracted strikes have taught—nay, have forced—other nations to develop their own coal fields, and the result is that there is no longer the keen demand that there used to be for British coal. The inevitable result of this superabundance of fuel in the world's markets is the lowness of price all round, and when prices continue low, as they have done and are doing, without any prospect of a rise, the weakest and worst-equipped collieries must close down, and once such a colliery is laid in for any length of time, the probabilities are decidedly against its being reopened."

If these pessimistic utterances have any real foundation, the day is within measurable distance when another Gibbon, rising from the ranks of the mining engineers, will give us a second classic, this time on "The Decline and Fall of the British Coal Industry."

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, LIVERPOOL, 1896.

ADDRESS TO THE MATHEMATICAL AND PHYSICAL SECTION.

By Prof. J. J. Thomson, M.A., F.R.S., President of the Section.

There is a melancholy reminiscence connected with this meeting of our Section, for when the British Association last met in Liverpool the chair in section A was occupied by Clerk-Maxwell. In the quarter of a century which has elapsed since that meeting, one of the most important advances made in our science has been the researches which, inspired by Maxwell's view of electrical action, confirmed that view, and revolutionised our conception of the processes occurring in the electro-magnetic field. When the Association last met in Liverpool, Maxwell's view was almost without supporters, to-day its opponents are fewer than its supporters then. Maxwell's theory, which is the development and extension of Faraday's, has not only affected our way of regarding the older phenomena of electricity, it has, in the hands of Hertz and others, led to the discovery of whole regions of phenomena previously undreamt of. It is sad to think that his premature death prevented him from reaping the harvest he had sown. His writings are, however, with us, and are a storehouse to which we continually turn, and never, I think, without finding something valuable and suggestive.

"Thus ye teach us day by day,
Wisdom, though now far away."

The past year has been rich in matters of interest to physicists. In it has occurred the jubilee of Lord Kelvin's tenure of the Professorship of Natural Philosophy at the University of Glasgow. Some of us were privileged to see this year at Glasgow, an event unprecedented in the history of physical science in England, when congratulations to Lord Kelvin on the jubilee of his professorship were offered by people of every condition and country. Every scientific society and every scientific man is Lord Kelvin's debtor; but no society and no body of men owe him a greater debt than Section A of the British Association; he has done more for this Section than anyone else, he has rarely missed its meetings, he has contributed to the Section papers which will make its proceedings imperishable, and by his enthusiasm he has, year by year, inspired the workers in this Section to renew with increased vigour their struggles to penetrate the secrets of nature. Long may we continue to receive from him the encouragement and assistance which have been so freely given for the past half century.

By the death of Sir W. R. Grove, the inventor of Grove's cell, we have lost a physicist whose name is a familiar one in every laboratory in the world. Besides the Grove cell, we owe to him the discovery of the gas battery, and a series of researches on the electrical behaviour of gases, whose importance is only now beginning to be appreciated. His essay on the correlation of the physical forces had great influence in promoting that belief in the unity of the various branches of physics which is one of the characteristic features of modern natural philosophy.

In the late Prof. Stoletow, of Moscow, we have lost the author of a series of most interesting researches on the electrical properties of gases illuminated by ultra-violet light, researches which, from their place of publication, are, I am afraid, not so well known in this country as they deserve to be.

As one who, unfortunately, of late years has had only too many opportunities of judging of the teaching of science in our public and secondary schools, I should like to bear testimony to the great improvement which has taken place in the teaching of physics in these schools during the past 10 years. The standard attained in physics by the pupils of these schools is increasing year by year, and great credit is due to those by whose labours this improvement has been accomplished. I hope I may not be considered ungrateful if I express the opinion that in the zeal and energy which is now spent in the teaching of physics in schools, there may lurk a temptation to make the pupils cover too much ground. You may by careful organisation and arrangement ensure that boys shall be taken over many branches of physics in the course of a short time; it is, indeed, not uncommon to find boys of 17 or 18 who have compassed almost the whole range of physical subjects. But although you may increase the rate at which information is acquired, you cannot increase in anything like the same proportion the rate at which the subject is assimilated, so as to become a means of strengthening the mind and a permanent mental endowment when the facts have long been forgotten.

Physics can be taught so as to be a subject of the greatest possible educational value, but when it is so it is not so much because the student acquires a knowledge of a number of interesting and important facts, as by the mental training the study affords in, as Maxwell said, "bringing our theoretical knowledge to bear on the objects, and the objects on our theoretical knowledge." I think this training can be got better by going very slowly through such a subject as mechanics, making the students try innumerable experiments of the simplest, and, what is a matter of importance in school teaching, of the most inexpensive kind, but always endeavouring to arrive at numerical results, rather than by attempting to cover the whole range of mechanics, light, heat, sound, electricity, and magnetism. I confess I regret the presence in examinations intended for school boys of many of these subjects.

I think, too, that in the teaching of physics at our universities there is, perhaps, a tendency to make the course too complex and too complete. I refer especially to the training of those students who intend to become physicists. I think that after a student has been trained to take accurate observations, to be alive to those pitfalls and errors to which all experiments are liable, mischief may in some cases be done if, with the view of learning a knowledge of methods, he is kept performing elaborate experiments, the results of which are well known. It is not given to many to wear a load of learning lightly as a flower. With many students a load of learning, especially if it takes a long time to acquire, is apt to crush enthusiasm. Now, there is, I think, hardly any quality more essential to success in physical investigations than enthusiasm. Any investigation in experimental physics requires a large expenditure of both time and patience; the apparatus seldom, if ever, begins by behaving as it ought; there are times when all the forces of nature, all the properties of matter, seem to be fighting against us; the instruments behave in the most capricious way, and we appreciate Coutts Trotter's saying, that the doctrine of the constancy of nature could never have been discovered in a laboratory. These difficulties have to be overcome, but it may take weeks or months to do so, and, unless the student is enthusiastic, he is apt to retire disheartened from the contest. I think, therefore, that the preservation of youthful enthusiasm is one of the most important points for consideration in the training of physicists. In my opinion this can best be done by allowing the student, even before he is supposed to be acquainted with the whole of physics, to begin some original research of a simple kind under the guidance of a teacher who will encourage him and assist in the removal of difficulties. If the student once tastes the delights of the successful completion of an investigation, he is not likely to go back, and will be better equipped for investigating the secrets of nature than if, like the White Knight of "Alice in Wonderland," he commences his career knowing how to measure or weigh every physical quantity under the sun, but with little desire or enthusiasm to have anything to do with any of them. Even for those students who intend to devote themselves to other pursuits than physical investigation, the benefits derived from original investigation as a means of general education can hardly be over-estimated, the necessity it entails of independent thought, perseverance in overcoming difficulties, and the weighing of evidence gives it an educational value which can hardly be rivalled. We have to congratulate ourselves that through the munificence of Mr. Ludwig Mond, in providing and endowing a laboratory for research, the opportunities for pursuing original investigations in this country have been greatly increased.

The discovery at the end of last year by Prof. Röntgen of a new kind of radiation from a highly exhausted tube through which an electric discharge is passing, has aroused an amount of interest unprecedented in the history of physical science. The effects produced *inside* such a tube by the cathode rays, the bright phosphorescence of the glass, the shadows thrown by opaque objects, the deflection of the rays by a magnet, have, thanks to the researches of Crookes and Goldstein, long been familiar to us, but it is only recently that the remarkable effects which occur outside such a tube have been discovered. In 1893, Lenard, using a tube provided with a window made of a very thin plate of aluminium, found that a screen impregnated with a solution of a phosphorescent substance became luminous if placed outside the tube in the prolongation of the line from the cathode through the aluminium window. He also found that photographic plates placed outside the tube in this line were affected, and electrified bodies were discharged; he also obtained by these rays photographs through plates of aluminium or quartz. He found that the rays were affected by a magnet, and regarded them as the prolongations of the cathode rays. This discovery was at the end of last year followed by that of Röntgen, who found that the region round the discharge tube is traversed by rays which affect a photographic plate after passing through substances such as aluminium or cardboard, which are opaque to ordinary light; which pass from one substance to another, without any refraction, and with but little regular reflection; and which are not reflected by a magnet. We may, I think, for the purposes of discussion, conveniently divide the rays occurring in or near a vacuum tube traversed by an electric current into three classes, without thereby implying that they are necessarily distinctly different in physical character. We have (1) the cathode rays inside the tube, which are deflected by a magnet (2) the Lenard rays outside the tube, which are also deflected by a magnet; and (3) the Röntgen rays, which are not, as far as is known, deflected by a magnet. Two views are held as to the nature of the cathode rays; one view is, that they are particles of gas carrying charges of negative electricity, and moving with great velocities which they have acquired as they travelled through the intense electric field which exists in the neighbourhood of the negative electrode. The phosphorescence of the glass is on this view produced by the impact of these rapidly moving charged particles, though whether it is produced by the mechanical violence of the impact, or whether it is due to an electro-magnetic impulse produced by the sudden reversal of the velocity of the negatively charged particle—whether, in fact, it is due to mechanical or electrical causes, is an open question. This view of the constitution of the cathode rays explains in a simple way the deflection of those rays in a magnetic field, and it has lately received strong confirmation from the results of an experiment made by Perrin. Perrin placed inside the exhausted tube a cylindrical metal vessel with a small hole in it, and connected this cylinder with the leaves of a gold leaf electroscope. The cathode rays could, by means of a magnet, be guided so as either to pass into the cylinder through the aperture, or turned quite away from it. Perrin found that when the cathode rays passed into the cylinder the gold leaf of the electroscope diverged, and had a negative charge, showing that the bundle of cathode rays enclosed by the cylinder had a charge of negative electricity. Crookes had many years ago exposed a disc connected with a gold-leaf electroscope to the bombardment of the cathode rays, and found that the disc received a slight *positive* charge; with this arrangement, however, the charged particles had to give up their charges to the disc if the gold leaves of the electroscope were to be affected, and we know that it is extremely difficult, if not impossible, to get electricity out of a charged gas merely by bringing the gas in contact with a metal. Lord Kelvin's electric strainers are an example of this. It is a feature of Perrin's experi-

ment that since it acts by induction, the indications of the electroscope are independent of the communication of the charges of electricity from the gas to the cylinder, and since the cathode rays fall on the inside of the cylinder, the electroscope would not be affected, even if there were such an effect as is produced when ultra-violet light falls upon the surface of an electro-negative metal when the metal acquires a positive charge. Since any such process cannot affect the total amount of electricity inside the cylinder, it will not affect the gold leaves of the electroscope; in fact, Perrin's experiments prove that the cathode rays carry a charge of negative electricity.

The other view held as to the constitution of the cathode rays is that they are waves in the ether. It would seem difficult to account for the result of Perrin's experiment on this view, and also, I think, very difficult to account for the magnetic deflection of the rays. Let us take the case of a uniform magnetic field: the experiments which have been made on the magnetic deflection of these rays seem to make it clear that in a magnetic field which is sensibly uniform, the path of these rays is curved; now, if these rays were due to ether waves, the curvature of the path would show that the velocity of propagation of these waves varied from point to point of the path. That is, the velocity of propagation of these waves is not only affected by the magnetic field, it is affected differently at different parts of the field. But in a uniform field what is there to differentiate one part from another, so as to account for the variability of the velocity of wave propagation in such a field? The curvature of the path in a uniform field could not be accounted for by supposing that the velocity of this wave motion depended on the strength of the magnetic field, or that the magnetic field, by distorting the shape of the boundary of the negative dark space, changed the direction of the wave front, and so produced a deflection of the rays. The chief reason for supposing that the cathode rays are a species of wave motion is afforded by Lenard's discovery that when the cathode rays in a vacuum tube fall on a thin aluminium window in the tube, rays having similar properties are observed on the side of the window outside the tube; this is readily explained on the hypothesis that the rays are a species of wave motion to which the window is partially transparent, while it is not very likely that particles of the gas in the tube could force their way through a piece of metal. This discovery of Lenard's does not, however, seem to me incompatible with the view that the cathode rays are due to negatively charged particles moving with high velocities. The space outside Lenard's tube must have been traversed by Röntgen rays; these would put the surrounding gas in a state in which a current would be readily started in the gas if any electromotive force acted upon it. Now, though the metal window in Lenard's experiments was connected with the earth, and would, therefore, screen off from the outside of the tube any effect arising from slow electrostatic changes in the tube, it does not follow that it would be able to screen off the electrostatic effect of charged particles moving to and from the tube with very great rapidity. For in order to screen off electrostatic effects, there must be a definite distribution of electrification over the screen; changes in this distribution, however, take a finite time, which depends upon the dimensions of the screen and the electrical conductivity of the material of which it is made. If the electrical changes in the tube take place at above a certain rate, the distribution of electricity on the screen will not have time to adjust itself, and the screen will cease to shield off all electrostatic effects. Thus the very rapid electrical changes which would take place if rapidly moving charged bodies were striking against the window, might give rise to electromotive forces in the region outside the window, and produce convection currents in the gas which has been made a conductor by the Röntgen rays. The Lenard rays would thus be analogous in character to the cathode rays, both being convective currents of electricity. Though there are some points in the behaviour of these Lenard rays which do not admit of a very ready explanation from this point of view, yet the difficulties in its way seem to me considerably less than that of supposing that a wave in the ether can change its velocity when moving from point to point in a uniform magnetic field.

I now pass on to the consideration of the Röntgen rays. We are not yet acquainted with any crucial experiment which shows unmistakably that these rays are waves of transverse vibration in the ether, or that they are waves of normal vibration, or, indeed, that they are vibrations at all. As a working hypothesis, however, it may be worth while considering the question whether there is any property known to be possessed by these rays which is not possessed by some form or other of light. The many forms of light have in the last few months received a noteworthy addition by the discovery of M. Becquerel of an invisible radiation, possessing many of the properties of the Röntgen rays, which is emitted by many fluorescent substances, and to an especially marked extent by the uranium salts. By means of this radiation, which, since it can be polarised, is unquestionably light, photographs through opaque substances similar to, though not so beautiful as, those obtained by means of Röntgen rays, can be taken, and, like the Röntgen rays, they cause an electrified body on which they shine to lose its charge, whether this be positive or negative.

The two respects in which the Röntgen rays differ from light is in the absence of refraction, and, perhaps, polarisation. Let us consider the absence of refraction first. We know cases in which special rays of the spectrum pass from one substance to another without refraction; for example, Kundt showed that gold, silver, and copper allow some rays to pass through them without bending, while other rays are bent in the wrong direction. Pflüger has lately found that the same is true for some of the aniline dyes when in a solid form. In addition to this, the theory of dispersion of light shows that there will be no bending when the frequency of the vibration is very great. Helmholtz has shown the relation between the refractive index and the frequency of vibration for a substance whose molecules have a natural period of vibration, and one only. The refractive index increases with the frequency of the light until the latter is equal to the frequency of the natural vibration of the substance; the refractive index then diminishes, becomes less than unity, and finally approaches unity, and is practically equal to it when the frequency of the light greatly exceeds that of the natural vibration of the molecule. Helmholtz's results are obtained on the supposition that a molecule of the refracting substance consists of a pair of oppositely electrified atoms, and that the specific inductive capacity of the medium consists of two parts, one due to the ether, the other to the setting of the molecules along the lines of electric force.

Starting from this supposition, we can easily see, without mathematical analysis, that the relation between the refractive index and the frequency must be of the kind indicated by the curve. Let us suppose that an electromotive force of given amplitude acts on this mixture of molecules and ether, and let us start with the frequency of the external electromotive force less than that of the free vibrations of the molecules; as the period of the force approaches that of the molecules, the effect of the force in pulling the molecules into line will increase; thus the specific inductive capacity, and therefore the refractive index, increases with the frequency of the external force; the effect of the force on the orientation of the molecules will be greatest when the period of the force coincides with that of the molecules. As long as the frequency of the force is less than that of the molecules, the external field tends to make molecules set so as to increase the specific inductive capacity of the mixture; as soon, however, as the frequency of the force exceeds that of the molecules, the molecules, if there are no viscous forces, will all topple over and point so as to make the part of the specific inductive capacity due to the molecules of opposite sign to that due to the ether. Thus, for frequencies greater than that of the molecules, the specific inductive capacity will be less than unity. When the frequency of the force only slightly exceeds that of the molecules, the effect of the external field on the molecules is very great, so that if there are a considerable number of molecules, the negative part of the specific inductive capacity due to the molecules may be greater than the positive part due to the ether, so that the specific inductive capacity of the mixture of molecules and ether would be negative; no waves of this period could then travel through the medium, they would be totally reflected from the surface.

As the frequency of the force gets greater and greater, its effect in making the molecules set will get less and less, but the waves will continue to be totally reflected until the negative part of the specific inductive capacity due to the molecules is just equal to the positive part due to the ether. Here the refractive index of the mixture is zero. As the frequency of the force increases, its effect on the molecules gets less and less, so that the specific inductive capacity continually approaches that due to the ether alone, and practically coincides with it as soon as the frequency of the force is a considerable multiple of that of the molecules. In this case both the specific inductive capacity and the refractive index of the medium are the same as that of the ether, and there is consequently no refraction. Thus the absence of refraction, instead of being in contradiction to the Röntgen rays, being a kind of light, is exactly what we should expect if the wave length of the light were exceedingly small.

The other objection to these rays being a kind of light is, that there is no very conclusive evidence of the existence of polarisation. Numerous experiments have been made on the difference between the absorption of these rays by a pair of tourmaline plates when their axes are crossed or parallel. Many observers have failed to observe any difference at all between the absorption in the two cases. Prince Galitzine and M. de Karnojitsky, by a kind of cumulative method, have obtained photographs which seem to show that there is a slightly greater absorption when the axes are crossed than there is when the axes are parallel. There can, however, be no question that the effect, if it exists at all, is exceedingly small compared with the corresponding effect for visible light. Analogy, however, leads us to expect that to get polarisation effects we must use, in the case of short waves, polarisers of a much finer structure than would be necessary for long ones. Thus a wire bird-cage will polarise long electrical waves, but will have no effect on visible light. Rubens and Dubois made an instrument which would polarise the infra red rays by winding very fine wires very close together on a framework; this arrangement, however, was too coarse to polarise visible light. Thus, though the structure of the tourmaline is fine enough to polarise the visible rays, it may be much too coarse to polarise the Röntgen rays, if these have exceedingly small wave lengths. As far as our knowledge of these rays extends, I think we may say that though there is no direct evidence that they are a kind of light, there are no properties of the rays which are not possessed by some variety of light.

It is clear that if the Röntgen rays are light rays, their wave lengths are of an entirely different order to those of visible light. It is perhaps worth notice that on the electro-magnetic theory of light, we might expect two different types of vibration, if we suppose that the atoms in the molecule of the vibrating substance carried electrical charges. One set of vibrations would be due to the oscillations of the bodies carrying the charges, the other set to the oscillation of the charges on these bodies. The wave length of the second set of vibrations would be commensurate with molecular dimensions; can these vibrations be the Röntgen rays? If so, we should expect them to be damped with such rapidity as to resemble electrical impulses rather than sustained vibrations.

If we turn from the rays themselves to the effects they produce, we find that the rays alter the properties of the substances through which they are passing. This change is most apparent in the effects produced on the electrical properties of the substances. A gas, for example, while transmitting these rays, is a conductor of electricity. It retains its conducting properties for some little time after the rays have ceased to pass through it; but Mr. Rutherford and I have lately

found that the conductivity is destroyed if a current of electricity is sent through the Röntgenised gas. The gas in this state behaves in this respect like a very dilute solution of an electrolyte. Such a solution would cease to conduct after enough electricity had been sent through it to electrolyse all the molecules of the electrolyte. When a current is passing through a gas exposed to the rays, the current destroys and the rays produce the structure which gives conductivity to the gas; when things have reached a steady state, the rate of destruction by the current must equal the rate of production by the rays. The current can thus not exceed a definite value, otherwise more of the conducting gas would be destroyed than is produced.

This explains the very characteristic feature that in the passage of electricity through gases exposed to Röntgen rays the current, though at first proportional to the electromotive force, soon reaches a value where it is almost constant and independent of the electromotive force, and we get to a state when a tenfold increase in the electromotive force only increases the current by a few per cent. The conductivity under the Röntgen rays varies greatly from one gas to another, the halogens and their gaseous compounds, the compounds of sulphur, and mercury vapour, are among the best conductors. It is worthy of note that those gases which are the best conductors when exposed to the rays are either elements, or compounds of elements, which have in comparison with their valency very high refractive indices.

The conductivity conferred by the rays on a gas is not destroyed by a considerable rise in temperature; it is, for example, not destroyed if it be sucked through metal tubing raised to a red heat. The conductivity is, however, destroyed if the gas is made to bubble through water, it is also destroyed if the gas is forced through a plug of glass wool. This last effect seems to indicate that the structure which confers conductivity on the gas is of a very coarse kind, and we get confirmation of this from the fact that a very thin layer of gas exposed to the Röntgen rays does not conduct nearly so well as a thicker one. I think we have evidence from other sources that electrical conduction is a process that requires a considerable space—a space large enough to enclose a very large number of molecules.

Thus Koller found that the specific resistances of petroleum, turpentine, and distilled water, when determined from experiments made with very thin layers of these substances, was very much larger than when determined from experiments with thicker layers. Even in the case of metals there is evidence that the metal has to be of appreciable size if it is to conduct electricity. The theory of the scattering of light by small particles shows that, if we assume the truth of the electro-magnetic theory of light, the effects should be different according as the small particles are insulators or conductors. When the small particles are non-conductors, theory and experiment concur in showing that the direction of complete polarisation for the scattered light is at right angles to the direction of the incident light, while if the small particles are conductors, theory indicates that the direction of complete polarisation makes an angle of 60° with the incident light. This result is not, however, confirmed by the experiments made by Prof. Threlfall on the scattering of light by very small particles of gold. He found that the gold scattered the light in just the same way as a non-conductor, giving complete polarisation at right angles to the incident light. This would seem to indicate that those very finely divided metallic particles no longer acted as conductors. Thus there seems evidence that in the case of conduction through gases, through badly conducting liquids and through metals, electric conduction is a process which requires a very considerable space and aggregations of large numbers of molecules. I have not been able to find any direct experimental evidence as to whether the same is true for electrolytes. Experiments on the resistance of thin layers of electrolytes would be of considerable interest, as according to one widely accepted view of electrolysis conduction through electrolytes, so far from being effected by aggregations of molecules, takes place by means of the ion, a structure simpler than that of the molecule, so that if this represents the process of electrolytic conduction, there would not seem room for the occurrence of an effect which occurs with every other kind of conduction.

In this building it is only fitting that some reference should be made to the question of the movement of the ether. You are all doubtless acquainted with the heroic attempts made by Professor Lodge to set the ether in motion, and how successfully the ether resisted them. It seems to be conclusively proved that a solid body in motion does not set in motion the ether at an appreciable distance outside it, so that if the ether is disturbed at all in such a case, the disturbance is not comparable with that produced by a solid moving through an incompressible fluid, but must be more analogous to that which would be produced by the motion through the liquid of a body of very open structure, such as a piece of wire netting, where the motion of the fluid only extends to a distance comparable with the diameter of the wire, and not with that of the piece of netting. There is another class of phenomena relating to the movement of the ether which is, I think, deserving of consideration, and that is the effect of a varying electro-magnetic field in setting the ether in motion. I do not remember to have seen it pointed out that the electro-magnetic theory of light implicitly assumes that the ether is not set in motion even when acted on by mechanical forces. On the electro-magnetic theory of light such forces do exist, and the equations used are only applicable when the ether is at rest. Consider, for example, the case of a plane electric wave travelling through the ether. We have parallel to the wave front a varying electric polarisation, which on the theory is equivalent to a current; at right angles to this, and also in the wave front, we have a magnetic force. Now, when a current flows through a medium in a magnetic field there is a force acting on the medium at right angles to the plane, which is parallel both to the current and to the magnetic force; there will thus be a mechanical force acting on each unit volume of the ether when transmitting an electric wave, and since this force is at right angles to the current and to the magnetic force, it will be in the direction in which the wave is propagated. In the electro-magnetic theory of light, however, we assume that this force does not set the ether in motion, as unless we made this assumption we should have to modify our equations, as the electro-magnetic equations are not the same in a moving field as in a field at rest. In fact, a complete discussion of the transmission of electro-magnetic disturbances requires a knowledge of the constitution of the other which we do not possess. We now assume that the ether is not set in motion by an electro-magnetic wave. If we do not make this assumption we must introduce into our equation quantities representing the components of the velocity of the ether, and unless we know the constitution of the ether, so as to be able to deduce these velocities from the forces acting on it, there will be in the equations of the electro-magnetic field more unknown quantities than we have equations to determine. It is, therefore, a very essential point in electro-magnetic theory to investigate whether or not there is any motion of the ether in a varying electro-magnetic field. We have at the Cavendish Laboratory, using Prof. Lodge's arrangement of interference fringes, made some experiments to see if we could detect any movement of the ether in the neighbourhood of an electric vibrator, using the spark which starts the vibrations as the source of light. The movement of the ether, if it exists, will be oscillatory, and with an undamped vibrator the average velocity would be zero; we used, therefore, a heavily damped vibrator, with which the average velocity might be expected to be finite. The experiments are not complete, but so far the results are entirely negative. We also tried by the same method to see if we could detect any movement of the ether in the neighbourhood of a vacuum tube emitting Röntgen rays, but could not find any trace of such a movement. Prof. Threlfall, who independently tried the same experiment, has, I believe, arrived at the same conclusion.

Unless the ether is immovable under the mechanical forces in a varying electro-magnetic field, there are a multitude of phenomena awaiting discovery. If the ether does move, then the velocity of transmission of electrical vibrations, and therefore of light, will be affected by a steady magnetic field. Such a field, even if containing nothing but ether, will behave towards light like a crystal, and the velocity of propagation will depend upon the direction of the rays. A similar result would also hold in a steady electric field. We may hope that experiments on these and similar points may throw some light on the properties of that medium which is universal, which plays so large a part in our explanation of physical phenomena, and of which we know so little.

ELECTRIC GLOW LAMP TESTS.

By William Henry Preece., C.B., F.R.S., &c.

(Read before Section G, on Monday, September 21st)

So much has been written on glow lamps, and so ably did Professor Ayrton and Mr. Medley treat the subject in a paper read before the Physical Society, on December 14th, 1894, and on January 25th, 1895, that it is now somewhat difficult to discuss any new question of commercial and scientific interest. However, as I have been investigating the quality of various glow lamps since the Edison-Swan patents expired in order to establish a fair and reasonable specification for the Post Office requirements, and to find, if possible, an expeditious as well as reliable way of testing the efficiency and durability of lamps submitted in competition and delivery, I thought the results oblained would not be unwelcome to the members of the British Association.

My experiments were conducted on the following lines:—

1. To find the efficiency and life of 100 and 105 volt 16 and 8 candle-power lamps in a trial of 2,000 hours' duration when kept alight continuously (night and day) at a constant voltage.
2. To ascertain the efficiency and life of lamps when similarly maintained at constant potential, but lighted for several consecutive hours daily, as in an ordinary installation.
3 and 4. Similar to 1 and 2, except that the duration of trial was limited to 1,000 hours.
5. To find the mean breaking voltage of filaments by gradually increasing the voltage for each lamp at about the same rate.
6. To see what the effect would be on similar filaments after being raised to three-fourths of their mean breaking voltage, as found by 5.

As several distinct series of experiments have been made by me since the end of 1894, it would perhaps be advisable to deal with them in groups.

The whole of the tests were carried out with continuous currents.

All the electrical measurements of voltage and current were made with a Hartmann and Braun Voltmeter, in conjunction with an Ayrton and Perry Twisted Strip Ampere Meter, and each instrument was frequently verified against a Standard d'Arsonval Galvanometer. A few secondary cells were used to regulate the pressure on the 105 volt circuit, and adjustable resistances were employed to maintain the required voltage at the ends of the respective lamps. (Fig. 1.)*

For the continuous lighting experiments each lamp was fitted in a proper lamp holder, attached to which was a short length of flexible twin conductor, and until the lamps were wanted for measurement they hung on hooks outside the photometer in positions marked to correspond with the lamps. To ascertain the candle power of any one of the lamps, it was passed through a small door into the Photometer space, and suspended from a clip on a carriage which could be moved over a graduated photometer bar.

* The curves referred to in this paper appear in the form of a special supplement with this issue.—Eds. Elec. Rev.

Between the months of February, 1894, and April, 1895, the following lamps were tried:—

Experiment.	Lamps. Volts.	C. P.	Supplied by
1 and 2	105	16	Messrs. The Edison Swan Co.
	100	16	
	105	16	,, Siemens Brothers
	100	8	
	100	16	,, The Brush Co.
	100	8	
	105	16	,, Laing, Wharton & Down.
	100	8	
	105	16	,, Stearn.
	100	10	
	105	16	,, The International Electric Co.
	100	8	
	105	16	,, The Bishop's Cluster Co.
	100	8	
	105	16	,, The Electrical Co., Ltd.
	105	8	
	105	16	,, The Sunbeam Lamp Co.
	100	8	
3 and 4	100	16	,, The Electrical Co., Ltd.
	105	8	
	105	16	,, Barclay & Son.
	105	16	,, Sturm & Co.
	105	8	
	105	16	,, P. Walters & Co.
	105	8	
	105	16	,, Conze & Simon.
	105	8	
	105	16	,, The General Electric Co. (Robertson).
	100	8	
	105	16	,, Lowcock, Hill & Co.
	105	8	
	105	16	,, J. Shaw (Gem).
	105	16	,, Rose & Bird.
	105	8	
	105	16	,, Mackey, Mackey & Co.
	105	16	,, The Edison & Swan Co.
5 and 6	105	16	,, The General Electric Co. (Robertson).
	105	16	,, G. Straus
	105	16	,, Sturm & Co.
	105	16	,, Conze & Simon
	105	16	,, Lowcock, Hill & Co.
	105	16	,, P. Walters & Co.
	111 to 119	11 to 16	(As now supplied by the Crystal Electric Lamp Co.

Group A.

Summarised Behaviour of Nominal 16 C.P. Lamps in 1,000 Hours.

Note.—The numbers I., II., &c., indicate number of lamp in trial.

Firm.	Initial C.P.	Percentage drop in 1,000 hours.	Percentage Efficiency Of Constancy in C.P.	Percentage Efficiency Comparative Electrical.	Mean of columns 4 and 5.	Remarks.
Edison-Swan. 100 v. (II.) ..	15·5	13·1	86·9	71·6	79·25	
International Electric Co. 105 v. (II.) ..	16·3	26·6	73·4	79·8	76·60	
Stearn. 105 v. (I.)	16·9	31·3	68·7	77·0	72.85	Only run 962 hours
Siemens Bros. 105 v. (III.)..	18·35	35·9	64·1	73·0	68·55	
Edison-Swan. 105 v. (I.) ..	16·9	39·0	61·0	69 5	65·25	1st 105 volt lamp tested. The 2nd 105 volt behaved more like the 100 volt lamp referred to above.
Electrical Co. 105 v. (I). ..	15·0	65·3	34·7	59·1	46·9	

The illuminating power of the lamp was balanced against Messrs. Sugg & Company's standard candles on Rumford's Shadow principle, and to ensure the greatest possible accuracy the mean value of the following three observations was recorded as the result:—

1. Through green glass;
2. Through red glass; and,
3. Without any vitreous medium while the two lights were carefully shaded from the observer's eyes.

Two lamps out of 24 of each make were selected at random, one 16-candle power, and one 8-candle power, of 105 and 100 volts. The voltage marked on the lamps was kept constant, and the current and candle power were carefully measured once in every 24 hours. If a lamp collapsed within the pre-arranged 2,000 hours' trial, its life was noted, and another lamp substituted without delay. From the results obtained, the following curves, A, B, C and D, of "candle-power and life" and "watts per candle and life" have been prepared for 16-candle power and 8-candle power lamps, comprised in Groups A and B.

In addition to the above curves, the summaries for Groups A and B show, at the end of 1,000 hours the percentage drop in candle-power; and the "comparative electrical efficiency" calculated on the assumption that an Edison-Swan 105 volt nominal 16 candle-power lamp, taking 3·75 watts per candle, is 100 per cent. efficiency. From the corresponding curves the behaviour of any one lamp at intervals of 100 hours can easily be obtained if required.

The following four lamps started considerably below the stated 16 C.P., and are therefore regarded as of no comparative value.

Bishop's Cluster Co. 105. (I.)	14·0	11·9					
Laing, Wharton & Down. 105. (II.)	13·1	22·5					
Brush Co. 100. (I.)	13·0	7·8					
Sunbeam Lamp Co. 105. (I.)	12·0	22·6					

Group A.

Summarised behaviour of Nominal 8 C.P. Lamps in 1,000 hours.

Note.—Numbers I., II., &c. indicate number of lamp in trial.

Firm.	Initial C.P.	Percentage drop in 1,000 h.	Percentage Efficiency of constancy in C.P.	Percentage Efficiency comparative Elect.	Mean of Colmns. 4 and 5.	Remarks.
Sunbeam Lamp Co. 100 v. (I.)	9.0	14·4	85·6	75·3	80·45	
International Electrical Co. 100 v. (II.) ..	9·08	25·9	74·1	78·6	76 35	
Siemens Bros. 100 v. (I.) ..	10·0	34·0	66·0	81·5	73·5	
Laing, Wharton & Down. 100 v. (II.)	9·2	57·6	42·4	66·0	54·2	
Stearn. 100 v. (I.)	10·3	61·9	38·1	65·8	51·95	Nomina 10 c.p.

The following three lamps started considerably below the stated 8 C.P., and are therefore regarded as of no comparative value.

Brush Co. 100 v. (II.)	6·6	5·42					
Electrical Co. 105 v. (I.) ..	6·4	49·4					
Bishop's Cluster Co. 100 v. (I.)	3·5	13 7					

Group B.

Summarised behaviour of Nominal 16 C.P. Lamps in 1,000 Hours.

Firm	Initial C.P.	Percentage drop in 1,000 h.	Percentage Efficiency of constancy in C.P.	Percentage Efficiency comparative Elect.	Mean of Colmns. 4 and 5.	Remarks.
Rose and Bird 105 v. 16 ..	16·5	20·0	80·0	81·2	80·6	
James Shaw 105 v. 16 ..	16·0	22·5	77·5	78·5	77·0	
Electrical Co. 105 v. 16 ..	15·6	19·9	80·1	73·5	76·8	
Barclay & Son 105 v. 16 ..	15·2	30·3	69·7	77·3	73·5	
Conze & Simon 105 v. 16 ..	15·7	35·7	64·3	72·8	68·5	
General Electric Co. 105 v. 16	19·7	41·1	58·9	71·7	65 3	Only lasted 982 hours.

The following four lamps started considerably below the stated 16 C.P., and are therefore regarded as of no comparative value.

Stürm & Co. 105 v, 16 ..	14·5	26·9				Only lasted 895 hours.
P. Walters & Co. 105 v. 16 ..	14·1	21·9				
Lowcock, Hill & Co. 105 v. 16	14·0	18·6				Only lasted 945 hours.
G. Straus. 105 v. 16	12·1	14·9				

The curves A, B, C, and D seem to indicate four classes of lamps:—

1. Those that start at about their nominal candle power at a high efficiency, but very quickly shew a decided falling off in candle power and efficiency, and become practically useless in four or five hundred hours.
2. Those that start off at about their nominal candle power, give a useful light for about a thousand hours, and then burn out.
3. Those that start off like 2, but do not break; and
4. Those that start off with a candle power below their nominal value, and keep it up fairly constant for 2,000 hours, or more.

Group E.

Summarised Behaviour of Nominal 16 C.P. Lamps in 1,000 Hours.

Firm.	Initial C.P.	Percentage drop in 1,000 hours.	Percentage Efficiency. Of Constancy in C.P.	Percentage Efficiency. Comparative Electrical.	Mean value of 4 and 5.	Remarks.
Stearn. (A. 1). 105 volts. 16 C.P.	19·7	50·25	49·75	60·4	55 07	
Stearn. (A. 2). 105 volt. 16 C P.	20·2	55·69	44·31	55 2	49·75	
Vaughan & Brown. 105 volts. 16 C.P.	15·3	22·9	77·1	69·0	73·1	

The following five lamps started considerably below the stated 16 C.P., and are therefore regarded as of no comparative value.

Gabriel & Angenault. 105 volts. 16 C.P. (1). ..	12·4	32·99 (793 hrs)	67·01	92·6	79·82	Lamp burned 793 hours.
Gabriel & Angenault. 105 volt. 16 C.P. (III.)	9·7	10 3	85·7	91·5	90·6	
Stearn. (1). 105 volt. 16 C.P.	13.3	30·1	69·9	58 3	64·1	
Stearn. (2). 105 volts. 16 C.P.	14·1	34·1	65·9	57.6	61·7	
Lux. 100 volt 16 C.P.	12	5·75 (757 hrs)	94·25	66·1	80 18	Lamp filament broken after 757 hrs.

Summarised behaviour of Nominal 8 and 12 C.P. Lamps in 1,000 Hours.

Firm.	Initial C.P.	Percentage drop in 1,000 h.	Percentage Efficiency of constancy in C.P.	Percentage Efficiency comparative Elect.	Mean value of 4 and 5.	Remarks.
Stearn. (A. 1) 105 volts. 8 C.P.	8·52	46·0	54·0	63·2	58·6	
Stearn. (A. 2) 105 volts. 8 C.P.	8·43	43·4	56 6	68·1	62·3	
Stearn. (No. 1) 105 volts. 8 C.P.	8·5	18·8	81·2	72 5	76·8	
Stearn. (No. 2) 105 volts. 8 C.P.	8·4	40·7	59·3	63·8	61·5	
(No. 1) Lamps as now made by the Crystal Electric Lamp Cmpny. 57 v. 12 C.P.	11·6	30·17	69·83	65·8	67·8	
(No. 2) „ „ 57 v. 12 C.P.	11 27	26·7	73 3	67·0	70·01	

The lamp below started considerably below the stated 8 C.P., and is therefore regarded as of no comparative value.

Gabriel & Angenault. 100 volt. 8 C.P.	5·52	+ 6·4	106·4	75 3	90·8	

Group E.

Summarised behaviour of Lamps marked 16 C.P. and 8 C.P. in 1,000 Hours. It will be seen below that only one lamp (Lotz-Abbott, 100 volts. 8 C.P. No. II.) out of the eight tested, gave the right candle-power at the start.

Firm.	Initial C.P.	Percentage drop in 1,000 h.	Percentage Efficiency of constancy in C.P.	Percentage Efficiency comparative Elect.	Mean value of 4 and 5.	Remarks.
Lux. 100 v. 16 C.P. (III.)	14·3	7·0	93·0	87·5	90·25	
Svea. 105 v. 16 C.P. ..	14·3	25·87	74·13	84·1	79·11	
Lotz-Abbott. 100 v. 16 C.P. (I.) ..	9·1	10·4	89·6	52·7	71·1	
Lotz-Abbott. 100 v. 16 C.P. (II.)..	13 3	5 26	94·74	78·3	86·72	
Lotz-Abbott. 100 v. 8 C.P. (I.) ..	7·0	+ 5·71	105·71	81·6	93·6	
Lotz-Abbott. 100 v. 8 C.P. (II.) ..	7·9	0	100	75·9	87·95	
Greenhill. 100 v. 8 C.P. (II.) ..	7·3	12·3	87·7	64·9	76·3	

The lamp below started considerably below the stated 8 C.P., and is therefore regarded as of no comparative value.

Greenhill. 100 v. 8 C.P. (I.) ..	6·4	16·4	83·6	59·0	71·3	

With Class 1 lamps, frequent renewals of lamps will be necessary to keep up a satisfactory light on any installation of considerable magnitude, but, as will appear later on, it would seem that my old predeliction of a "short life and a merry one" is not to be disregarded.

Classes 2 and 3 are apparently the most promising lamps for practical use, while

Those in Class 4 scarcely admit of fair comparison with the others in that they never reach their nominal candle power.

Throughout the prolonged tests of "continuous lighting," it will be seen from the data supplied, how the candle power of each lamp gradually dropped from the start to finish, and the watts per candle rose.

The next experiments were conducted between April, 1895 and February, 1896, and the results are shown in Group E.

In this Group (E) I met with several lamps which supported Professor Ayrton's investigations, that is, the candle power increased at first, and then diminished.

A so-called 100 volt 8 candle power Gabriel and Angenault lamp began at 5½ candles, and remained practically constant during the first 400 hours. It then gradually rose 10 per cent. (6·18 candles) to the 800th hour, after which the light slowly diminished to the starting luminosity, but the watts per candle were then higher than at the beginning of the trial.

Lotz Abbot Lamp 100 v., 16 c.p. (No. 2) rose from 13·3 to 14 candles in 400 hours, and then fell continuously.

„ „ „ 100 v., 8 c.p., began at 7 and increased to 7·9 candles in 500 hours and then dropped gradually. In 1,400 hours the candle power was the same as at the commencement of the test. The watts per candle varied from 5 at the start to 4.71 at the 1,400 hour point.

Two other lamps, as made by Stearn and the Crystal Electric Lamp Company slightly increased in candle power up to 200 hours, and then slowly diminished.

Installation Tests.

In the case of experiments 2 and 4, the lamps were rigidly mounted in suitable holders upon a stout shelf, fixed to a massive wall, so that no undue vibration should tend to shorten their life. The first group tried comprised two 8-candle power lamps and two 16-candle power lamps, as received from each of the firms mentioned against Experiment 2 in the above list, while a second batch of lamps comprised one 16-candle power and one 8-candle power, as supplied by each firm named against Experiment 4. Two circuits were formed, one for 100 volt, and one for 105 volt lamps, on identically the same system as that described for the continuous lighting tests, The illuminating power, and current of each lamp at its normal voltage, were taken before the trials commenced. Daily electrical measurements were made of each pair of lamps during the trial, and at the conclusion of the trial the existing lamps were again photometrically and electrically examined. If a lamp broke within the allotted 1,000 hours run, it was immediately replaced by another of the same make and kind of known efficiency. Hence, in the two following schedules, lettered respectively C and D, the number of lamp corresponds to the 1st, 2nd, 3rd, 4th, &c., lamp installed. The so-called economical or high efficiency lamps evidently suffered more than those of about 3½ watts per candle. In some cases the life was less than that of the same sort of lamps in the continuous lighting tests, while in other cases no difference was observable. Of seven economical lamps supplied by one firm, five of the filaments broke within 1,056½ hours. Schedules C and

Schedule C.

SUMMARY OF ORDINARY INSTALLATION TEST.

Lamps 105 and 100 volts, 16 C.P.

Two Lamps of each Maker in Parallel.

Firm.	Date of Starting.	Lamps in Parallel.	Current in Amperes.		Lamp.		Numbers of Lamps. 1	2	3	4	5	6	7	Candle Power at Finish.	Remarks.
			At Start.	At Finish.	Broke.	Date.	Lamp Hours.								
Edison Swan. 105 volts.	Feb. 1	Nos. 1 and 2	1·17	1·15	No. 2	Feb. 26	..	115	..	..	..	..	..	..	
	,, 26	,, 1 ,, 3	1·14	1·09	No. 1	May 1	471	..	..	..	..	..	..	..	
	May 1	,, 3 ,, 4	1·10	1·10	..	..	..	..	1030·5 unbroken	597	..	..	..	No. 3 11·4 ,, 4 12·3	
Siemens Bros. 105 volts..	Feb. 1	,, 1 ,, 2	1·14	1·04	..	..	1056·5 unbroken	1056·5	..	..	..	..	..	No. 1 9·4 ,, 2 10·0	
Brush Co. 100 volts.	Feb. 1	,, 1 ,, 2	1·13	1·06	..	..	1056·5 unbroken	1056·5	..	..	..	..	..	No. 1 9·6 ,, 2 11·6	
Laing, Wharton and Down. 105 volts.	Feb. 1	,, 1 ,, 2	1·01	0·97	No. 1	Mar. 28	213·5	..	..	..	..	..	..	..	
	March 28	,, 2 ,, 3	1·01	0·91	No. 3	July 4	..	..	678	..	..	..	..	..	
	July 4	,, 2 ,, 4	0·93	0·92	..	..	..	1056·5 unbroken	..	186 unbroken	..	..	..	No. 2 3·8 ,, 4 11·7	
Stearn. 105 volts.	Feb. 1	,, 1 ,, 2	1·17	1·12	No. 1	July 14	945·5	..	..	..	..	..	..	..	
	July 14	,, 2 ,, 3	0·93	0·92	..	..	..	1056·5 unbroken	102	..	..	..	..	No. 2 12·9 ,, 3 14·8	
International Electric Co. 105 volts.	Feb. 1	,, 1 ,, 2	1·24	1·10	No. 1	May 17	566	..	..	..	..	..	..	..	
	May 17	,, 2 ,, 3	1·08	1·02	..	..	..	1056·5 unbroken	450·5	..	..	..	..	No. 2 10·8 ,, 3 10·9	
Bishop's Cluster Co 105 volts.	Feb. 1	,, 1 ,, 2	1·11	1·04	..	..	1056·5 unbroken	1056·5	..	..	..	..	..	No. 1 10·3 ,, 2 9·7	
Electrical Co. 105 volts.	Feb. 1	,, 1 ,, 2	0·78	0·71	No. 1	Feb. 10	23·75	..	..	..	..	..	..	..	
	,, 10	,, 2 ,, 3	0·72	0·70	No. 2	,, 17	..	69	..	..	..	..	..	..	
	,, 19	,, 3 ,, 4	0·72	0.71	No. 3	,, 20	..	..	53·75	..	..	..	..	..	
	,, 20	,, 4 ,, 5	0·71	0·68	..	..	..	..	..	1006·5 unbroken	..	..	..	..	
	March 8	,, 4 ,, 6	0·70	0·56	No. 5	Mar. 8	..	..	..	..	101·5	..	..	..	
	June 11	,, 4 ,, 7	0·60	0·56	No. 6	June 11	..	..	..	..	..	532·75	328·5 unbroken	No. 4 4·3 ,, 7 6·5	
Sunbeam Lamp. 105 volts.	Feb. 1	,, 1 ,, 2	1·10	1·07	..	..	1014·5 unbroken	1014·5	..	..	..	..	..	No. 1 6·8 ,, 2 6·9	

D also show the life of each lamp, the current at start and finish, and the candle-power of those lamps burning at the conclusion of the trial. The longest run was 1,056½ hours, and the shortest 23¾ hours. Omitting these numbers and others below 100, the average life of *eight* 16-candle power 105 volt lamps was 463·47 hours, and of three 8-candle power 100 volt lamps 556 hours. Schedules C and C_1 include the same kind of lamps as those bracketed against experiments 1 and 2 in the preceding list, and Schedule D embraces lamps similar to those named in the same list opposite experiments 3 and 4.

Schedule C_1.

SUMMARY OF ORDINARY INSTALLATION TEST.

Lamps 100 Volt and 8 Candle Power.

Two Lamps of each Maker, in Parallel.

Firm.	Date of Starting.	Lamps in Parallel.	Current in Amperes.		Lamp.		Numbers of Lamps. Lamp Hours.				Candle Power at Finish.	Remarks.
			At Start.	At Finish.	Broke.	Date.	1	2	3	4		
Edison Swan. 100 volts 16 C.P. ..	Feb. 1	Nos. 1 and 2	1·24	1·22	..	..	1056·5 unbroken	1056·5	..	..	(No. 1 12·2 „ 2 12·3	16 Nominal Candle Power.
Siemens Bros. 100 volts.	Feb. 1	„ 1 „ 2	0·75	0·66	..	..	1056·5 unbroken	1056·5	..	..	(No. 1 9·4 „ 2 10·0	
Brush Co. 100 volts.	Feb. 1	„ 1 „ 2	0·55	0·51	..	..	1056·5 unbroken	1056·5	..	..	(No. 1 6·5 „ 2 3·7	
Laing, Wharton and Down. 100 volts.	Feb. 1	„ 1 „ 2	0·60	0·52	No. 1	May 18	574	..	..	..	(No. 2 3·2 „ 3 5·8	
		„ 2 „ 3	0·57	0·53	..	..	..	1056·5 unbroken	480·5	..		
Stearn. 100 volts.	Feb. 1	„ 1 „ 2	0·55	0·46	No. 2	April 4	..	258·25	..	..	(No. 3 5·1 „ 4 5·9	10 Nominal Candle Power.
		„ 1 „ 3	0·52	0·48	No. 1	June 27	835·5	..	..	..		
		„ 3 „ 4	0·53	0·51	..	..	..	..	787·5 unbroken	222·5		
International Electric Co. 100 volts.	Feb. 1	„ 1 „ 2	0·68	0·60	..	..	1056·5 unbroken	1056·5	..	..	(No. 1 5·4 „ 2 6·5	
Bishop's Cluster Co. 100 volts.	Feb. 1	„ 1 „ 2	0·81	0·79	..	..	1056·5 unbroken	1056·5	..	..	(No. 1 6·2 „ 2 4·9	
Electrical Co. 105 volts.	Feb. 1	„ 1 „ 2	0·45	0·39	..	..	1056·5 unbroken	1056·5	..	..	(No. 1 3·0 „ 2 2·7	
Sunbeam Lamp Co. 100 volts.	Feb. 13	„ 1 „ 2	0·85	0·83	..	..	1016·5 unbroken	1016·5	..	..	(No. 1 8·5 „ 2 5·4	

EXPERIMENT 5.—BREAKING VOLTAGE.

Having obtained a fairly good knowledge of the efficiency and durability of various glow lamps, under conditions of constant illumination and intermittent lighting, I next attempted to determine a quick and ready way of satisfactorily judging the quality of lamps. To obtain this end the voltage of several of the lamps already referred to was gradually run up for each lamp singly at a uniform rate, until the filaments broke. At the moment of rupture the voltage, current, and time of running up were noted in each case. Before increasing the normal voltage, the current of every lamp was carefully measured, and the resistance (hot) afterwards calculated. In later trials the resistance (cold) was also found.

Schedule D.

SUMMARY OF ORDINARY INSTALLATION TEST.

Lamps of 105 Volt, 16 C.P., and 8 C.P.

Two Lamps of each Make in Parallel.

Firm.	Date of Starting.	Lamps in Parallel.		Current in Amperes.				Lamp.		Lamp Hours.						C.P.		Remarks.
				At Start.		At Finish.										At Start.	At Finish.	
		16 C.P.	8 C.P.	16 C.P.	8 C.P.	16 C.P.	8 C.P.	Broke.	Date.	1	2	3	4	5	6			
Conze & Simon	Sept. 21/94	No. 1	No. 2	0·60	0·27	0·64	0·29	..	..	1076·5 unbroken		..	..	..	..	No. 1 10·6	12·5	
Barclay & Son	Sept. 21/94	„ 1	„ 2	0·49	0·26	0·51	0·24	No. 1	Jan. 16/95	759	1076·5 unbroken	..	..	..	..	„ 2 4·5	6·4	
	Jan. 16/95	„ 3	..	0·51	..	0·52	..	..	..	..	317·5 unbroken	..	..	..	..	6·2	5·6	
Stürm & Co. ..	Sept. 21/94	„ 1	„ 2	0·60	0·28	0·63	0·28	„ 2	Oct. 5/94	1076·5 unbroken	92·75	..	..	..	..	..	..	
	Oct. 5/94	..	„ 3	..	0·28	..	0·27	„ 3	Nov. 1/94	..	..	191·25	..	..	..	10·4	13·3	
	Nov. 1/94	..	„ 4	..	0·27	..	0·28	„ 4	Jan. 10/95	..	..	..	436.5	..	..	..	..	
	Jan. 10/95	..	„ 5	..	0·28	..	0·28	„ 5	Jan. 21/95	..	..	..	..	64	..	..	..	
	Jan. 21/95	..	„ 6	..	0·28	..	0·25	„ 6	Mar. 2/95	..	..	..	..	..	295 unbroken	..	..	
Walters & Co.	Sept. 21	„ 1	„ 2	0·54	0·37	0·54	0·34	..	..	1076·5 unbroken		..	..	..	..	No. 1 12·8	9·8	
Electrical Co..	Sept. 21	„ 1	„ 2	0·63	0·29	0·62	0·25	..	..	1076·5 unbroken		..	..	..	..	„ 2 7·3	7·3	
General Electric Co.		100 v. 16 c.p.	100 v. 16 c.p.	100v. 16c.p.	100v. 16c.p.	100v. 16c.p.	..									No. 1 15·0	12·0	
	Sept. 21	„ 1	No. 2	0·66	0·70	0·66	..	„ 1	Oct. 27/94	248	..	..	..	..	..	„ 2 8·7	5·4	
	Oct. 29/94	„ 3	..	0·70	..	0·65	0.67	„ 2	Dec. 3/94	..	..	824·5 unbroken	..	..	..	..	..	
	Dec. 3/94	..	„ 4	..	0·67	..	0·68	„ 4	Jan. 29/95	..	..	..	390·5	..	..	..	..	
	Jan. 29/95	..	„ 5	..	0·68	..	0.70	..	..	..	..	..	..	233 unbroken	..	..	..	
		105 v. 16 c.p.	105 v. 9 c.p.	105v. 8c.p.		105v. 8c.p.												
G. Straus ..	Sept. 21/94	No. 1	No. 2	0·58	0·35	0·62	0·35	„ 2	Feb. 28/95	1076·5 unbroken	1058	..	..	..	..	13·0	11·3	
	Feb. 28/95	..	„ 3	..	0·35	..	0·35	..	..	..	..	19·5 unbroken	..	..	..	..	..	
Lowcock, Hill & Co.	Sept. 21/94	„ 1	„ 2	0·51	0·36	0·54	0·35	„ 1	Jan. 14/95	739·5	1076·5 unbroken	..	..	..	..	7·0	6·4	
	Jan. 14/95	„ 3	..	0·54	..	0·54	..	..	..	..	..	337 unbroken	..	..	..	..	..	
Rose & Bird ..	Sept. 21/94	„ 1	„ 2	0·54	0·30	0·56	0·32	..	..	1076·5 unbroken		..	..	..	..	No. 1 14·8	12·4	
																„ 2 5·5	7·1	

(*To be continued.*)

LIVERPOOL OVERHEAD RAILWAY.

By S. B. Cottrell, M.Inst. C.E., M.I. Mech. E., Engineer and General Manager.

(Read in Section G, British Association.)

In 1882 an Act was obtained by the Dock Board for the construction of the railway at an estimated cost of about £585,000, which was subsequently reduced to £466,000 for a system worked by electricity.

In 1888 the power to construct the railway was taken over by the present Overhead Railway Company, under the chairmanship of Sir Wm. B. Forwood, and the works, as designed by the engineers, Sir Douglas Fox and J. H. Greathead, Esq., were commenced by the contractor (the late Mr. Willans) in 1889.

The construction decided on was wrought iron girders, placed 22 feet centre to centre, at a normal span of 50 feet, at a height of 16 feet above the roadway, supported on columns which are built of two steel channels and two plates.

The columns are grouted into cast iron shoes, which are held down by bolts to concrete foundations, the size of which varied according to the nature of the ground, the weight being distributed at one ton to the square foot. The bottoms of the columns are protected against injury from passing wagons by cast iron bumpers. The longest span on the present railway is a bowstring span of 98 feet. The main girders carry a light projecting parapet, and a curved plate is put on the flange to form a continuous foot plate.

Between the girders is fixed a continuous flooring made of arch plates $\frac{5}{16}$ inch in thickness, bent to a radius of 12 inches, with a foot surface 16 inches wide on the top, riveted to intervening tee bars. The flooring is made watertight by means of channels between the arches, which are drained by outlets into longitudinal gutters which discharge into down spouts fixed on the columns. The keeping of the structure watertight was one of the obligations the company were under. The flooring combines great strength with lightness and a minimum of riveting, and at the same time is comparatively noiseless under traffic.

The structure was so designed that the girders and flooring were put together and riveted, and then transported over the structure after it was completed (a few spans being first erected in the ordinary way), and placed in position without interfering with the traffic underneath. For this a special form of erecting apparatus was provided, consisting of lattice girders supported on legs, the front pair of which travelled on the ground and hind pair travelled on the viaduct that was already built. On these lattice girders suitable cranes were erected so that the completed span could be launched forward into position. As many as twelve spans, ranging from 50 to 70 feet each, were fixed in five and a half working days, representing 650 feet of finished viaduct.

At four different places along the line opening bridges had to be provided. At the Stanley Dock a hydraulic swing bridge is built to enable vessels to pass to that dock, which is the only dock on the east side of the railway. This bridge is a double-decked one, carrying the Overhead Railway on the high level and the dock traffic on the lower level. The low level bridge is arranged with bascule leaves, so that barges and small craft can pass through without swinging the bridge. At three other points bascule bridges, worked by hydraulic power, are provided, to permit the passage of boilers, &c., which are too high to go underneath the main girders.

The permanent way, which is laid to a gauge of 4 feet 8½ inches, consists of flat-bottomed steel rails weighing 56 lbs. per yard, fixed on longitudinal sleepers, held down to the flooring by lugs riveted on to it, and keyed in with oak keys. The rails are fixed to the longitudinal sleepers by spikes and fang bolts.

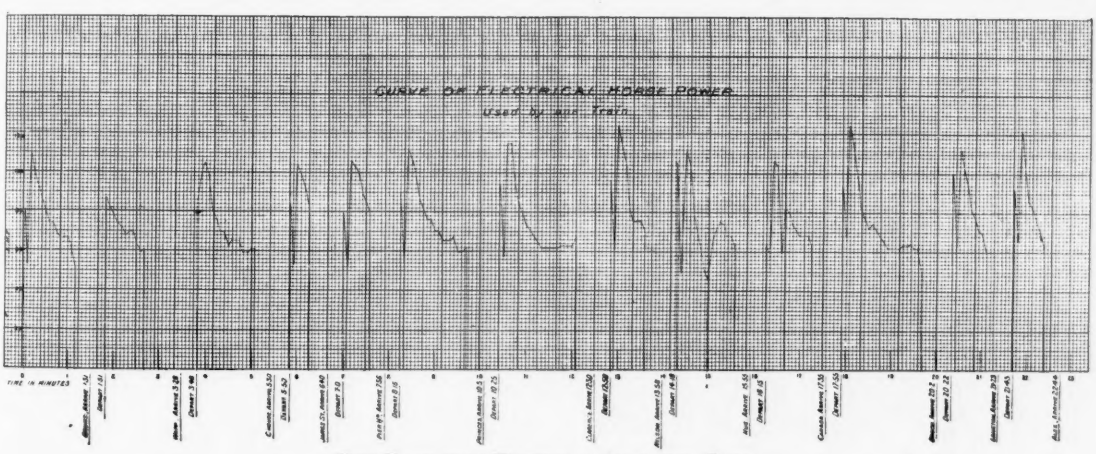
After careful consideration electric traction was decided on, and trains were built consisting of two carriages, each 45 feet long, 8 feet 6 inches wide, on two bogies 32 feet apart from centre pin to centre pin, with 2 feet 9-inch wheels. Each carriage contains seating accommodation for 16 first-class and 41 second-class passengers. The carriages have side doors and passage from end to end. Each carriage is fitted with electric motors, and the train is controlled by a driver from either end; this avoids all shunting at the terminal stations, the driver simply changing from end to end. The armatures for the motors are series wound (on the Eickmeyer system), and built directly upon the axle. The tractive force of each motor at rim of wheel, 2 feet 9 inches diameter, with 120 amperes, is about 1,790 lbs., equal to about 107 lbs. per ton of train. The motors are started up first in series, and then switched into parallel through a resistance with each motor, which is cut out to increase the speed.

The trains pick up the current from a conductor consisting of a steel bar, having an area of 4 square inches, supported on insulators carried on cross timbers between the two running rails. The conductor is laid in 32 feet lengths, connected with rigid copper fish-plates, with flexible joints every 96 feet. The running rails which are used for return electrical circuit, are, in addition to the fish-plates, coupled together with a bent wrought-iron bar.

Short trains, as described, run at frequent intervals, have proved up to the present time the best means of meeting the requirements. The trains are fitted with the Westinghouse automatic brake, supplied with compressed air, at 80 lbs. pressure, from reservoirs on trains which are charged at the terminal stations; they also have an emergency hand brake. A train fully loaded weighs 38 tons, of which the motor equipment is 6 tons 7 cwt. The carriages are lighted by 32-candle-power incandescent lights, supplied from the main conductor.

The generating station was put as near the centre of the line as a site could be obtained, and the first equipment consisted of six double flue Lancashire boilers, 30 feet long by 8 feet diameter, with a pressure of 120 lbs. The feed water is circulated through Green's economisers, and all steam pipes are in duplicate.

The engines are four in number, consisting of horizontal compound condensing engines, by Musgrave & Sons, of Bolton, the high pressure cylinders being 15½ inches, and low pressure 31 inches diameter, fitted with Corliss valves, driven by trip gear acted on directly by the governor. Each engine develops 400 I.H P. at 100 revolutions per minute, with 120 lbs. boiler pressure. The engines exhaust into surface condensers, the circulating air-pump for which is driven by a no-dead-centre vertical compound engine. The condensing plant is in duplicate. Each engine drives an Elwell-Parker dynamo, 500 amperes, 500 volts, of the double limb type, with magnetic circuit above and below the armature, the poles being cut through horizontally along the centre, to allow the top half to be lifted readily; they are shunt wound of drum type. The efficiency of the dynamos and engines is about 85 per cent. at full load. The current from dynamos is controlled by a switchboard, which is equipped with magnetic cut-outs, and works automatically in case of a short circuit, by which the current is conveyed to the centre conductor, and is picked up by collectors of cast-iron, fixed underneath the trains.



Test Train from Toxteth to Alexandra Dock.

The stations on the original line, 13 in number, subsequently increased to 16, are lit by electricity from batteries in duplicate on a 50-volt circuit, which also supply the current for working the signals.

Signals.

The signals are automatic (Timmis system), the arms being operated by magnets, which are controlled by *makers* and *breakers*, operated on by a striking board fixed on the last coach. The train in passing either *breaks* the circuit and puts the arm to danger, or *makes* the circuit and lowers the arm. Each station is equipped with a "home" and a "starter," the latter acting as a "distant." The circuit to lower the signals for the section in the rear of any station can only be completed if the "starting signal" is at danger, thus forming "absolute block." A train on leaving a station passes a *breaker* and puts the "starter" to danger, and after moving about 150 feet, passes a *maker*, which completes the circuit, and clears the section in the rear, leaving itself protected by the "starter."

This system dispenses with signalmen, they only being employed where shunting operations are carried on. Each station is equipped with a crossover road interlocked with the signals.

The total cost of the first portion of the railway, 5¾ miles in extent, was £90,000 per mile.

The earning power of the railway as at first constructed, and which was only worked for traffic as far as the Alexandra Dock, was limited, as passenger traffic on the docks practically ceases at 6 p.m.; and this

the directors foresaw, and in 1892 obtained powers to extend the railway both in a northern and southern direction.

The northern extension, ¼ mile in extent, but opening up another ¾ mile for traffic, was opened as far as Seaforth in 1894, and fully justifies its construction, the number of passengers carried having increased from 2,475,639 for the six months ending December 31st, 1894, to 3,780,375 for the six months ending December 31st, 1895.

Southern Extension.

The southern extension, ⅝ths of a mile long, which is now in course of construction, commences about 150 yards north of the present terminus of the railway, with a viaduct 250 yards long, crossing Sefton Street and the Brunswick goods yard of the Cheshire Lines Railway, a portion of the Dock Board Estate, and entering the hill side at the north-east corner of the Herculaneum Dock, and proceeds in a south-easterly direction to Park Road.

To meet the requirements of the Dock Board, their land is crossed by one span of about 200 feet, the main girders (which are of lattice type with parallel booms) being 220 and 225 feet respectively, and the whole of the span will weigh about 212 tons.

Underneath, where these big girders will rest at the face of the tunnel, are casements for storing petroleum, belonging to the Dock Board, extending about 60 feet into the hill, and to distribute the weight of the span over these, a bearing girder weighing 10 tons has been let in, and on this girder the east end of the span will rest. The west end will rest on a pier provided with rollers and rockers.

The normal tunnel has a span of 26 feet 2 inches springing to springing, and 25 feet 6 inches between side walls with a splayed plinth course; the arch is semi-circular. The tunnel for the station ground is 52 feet span, the arch being segmental, having ¼ span rise.

The tunnel is under house property the entire length, and it was, therefore, not always possible to sink shafts where they were desired. Five shafts 10 feet square were sunk, from the bottom of which headings 11 feet and 12 feet were driven in each direction, and the greatest error in line and level was under ¾ of an inch.

The tunnel portion—about 800 yards—is almost entirely through red sandstone rock, which, like all the rock in the neighbourhood of Liverpool, is of a very treacherous character, heavy backs and wet clay beds being frequently met with, necessitating heavy timbering, a large number of the crown bars had to be built in; the tunnel has therefore had to be lined throughout its entire length; all the lining is faced with brindle bricks built in cement. Black powder has been the chief explosive used in the excavation.

At about 170 feet from the entrance the tunnel crosses at an angle of 28° 27′ 40″ over the tunnel of Cheshire Lines Committee Railway, through which the trains of the M. S. and L., G. N. and Midland Railways run, and the greatest distance that could be allowed between the overhead rails and the crown of the Cheshire Lines tunnel 2 feet 9 inches.

After careful consideration, the engineers decided that the only safe way to effectually make the crossing was by turning a segmental screen arch, five rings thick, built with brindle bricks in cement, over the Cheshire Lines arch, and to build side walls of the overhead tunnel on this screen arch. This was carried out as follows:—A top heading 120 feet in length was driven along the crown of the Cheshire Lines tunnel, and then 8 feet lengths were excavated, baring the Cheshire Lines arch for that length. The exposed arch was then haunched with concrete, and the screen arch turned on sand, with ½-inch narrow boards placed on it, and when the arch was set, the sand and boards were withdrawn, leaving a clear space of 6 inches over the Cheshire Lines arch, so that no additional weight could come on the Cheshire Lines tunnel arch. During these operations all the rock above had to be carried on timber.

To guard against possible fall of rock which might crush through the Cheshire lines arch, before commencing the above operations a shield was put inside the Cheshire Lines tunnel. This shield was made of 8-inch × 5-inch H steel joists at 4 feet 3 inch centres, bent to the radius of the tunnel, and carrying 4-inch laggings, and keyed up tight by means of folding wedges to the soffit of the arch.

The Overhead Railway Company had also to provide for the Cheshire Lines at some future time, having to construct another tunnel on the east side of their existing tunnel; and, to avoid any interference with the traffic during the future, it was decided to build a length of tunnel arch seven rings thick, on which arch the Overhead Railway side walls are carried. All the excavation for this crossing has been done entirely by hand labour, and has proved a most expensive and anxious piece of work.

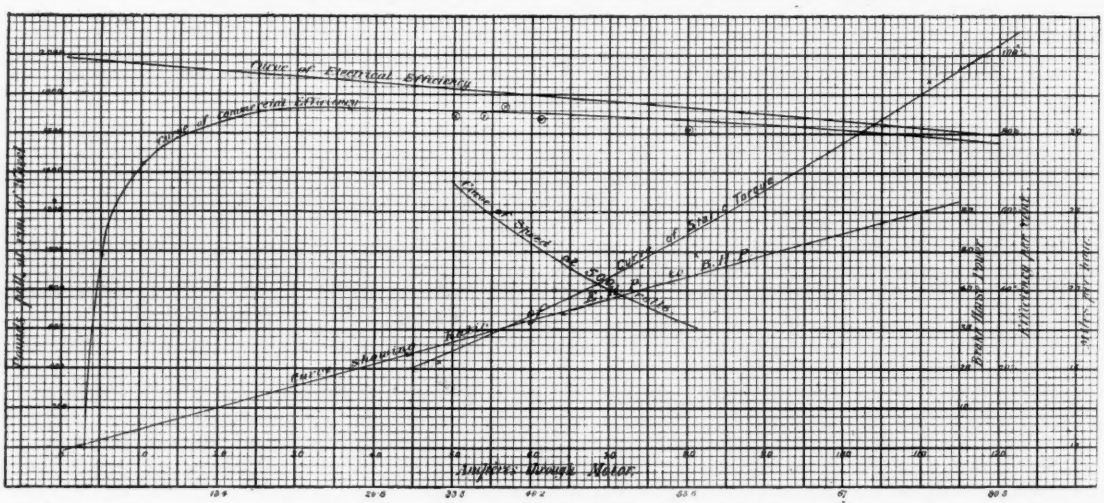
Further on the tunnel passes under a 5 feet × 3 feet sewer, and to avoid disturbing this, the arch was altered from semi-circular to segmental, which just permitted, with care, the sewer to be underpinned.

The trains on entering the tunnel will be automatically lit up from copper conductors suspended from the roof of tunnel, collectors being fixed on the roofs of the carriages. These lights will be fed off accumulators, so that if a train should be stopped in the tunnel, due to short-circuit on the line, the carriages will not be in darkness.

The terminal station of this extension is situated at Park Road, otherwise called the Dingle, below the road level. The underground station will consist of an island platform about 27 feet, with suitable sidings for accommodation of the trains. The station will be ventilated by a large upcast shaft. The access to the station will be by means of a subway at a gradient of 1 in 14. The booking offices will be on the road level.

The station will be lit throughout by electricity, the under-

Curves of Torque, Efficiency and Speed of Liverpool Overhead Railway Motor.



Static Torque Curve, taken in the usual way by bolting lever on shaft and weighting it at measured distances along it till pull of current through motor is balanced.

Electrical Efficiency Curve takes into account the C^2R losses in the copper only. Resistance of armature and magnets in series is ·83 ohms, at a temperature of about 70° F. above atmosphere.

Commercial Efficiency Curve shows actual efficiency of motor at wheel, and is obtained by estimation of all the losses separately. The motor was made to drive a dynamo by a belt. The small discrepancy between these points and the Commercial Efficiency Curve is accounted for by the necessarily approximate allowance made for belt, though this was as accurate as circumstances would permit.

Electrical Horse-Power Delivered to Motor, Corresponding to above Amperes at 500 Volts.

ground portion by arc lamps at 110 volts, supplied by a transformer off the main current. Battery lights will be provided in the event of a short circuit on the line.

As the station platforms are considerably below the level of the sewers, the question of dealing with the drainage of the tunnel and sewage of water closets and urinals had to be considered, and it was decided to employ Shone's hydro-pneumatic system.

The permanent way and main conductor will be of the same section as on the present railway, but the rails are laid on the usual cross sleepers, with cast-iron chairs to distribute the pressure.

As more generating plant will be required to work the additional number of trains, it was decided to increase the size of the present generating station, and to run feeding cables a length of about two miles, so as to regulate the E.M.F. instead of building another generating station, as it was found that this method would cheapen the working costs. The addition to the generating station consists of two engines built by Messrs. Hick Hargreaves, and two new dynamos and switchboard, built by Messrs. T. Parker & Co., of Wolverhampton.

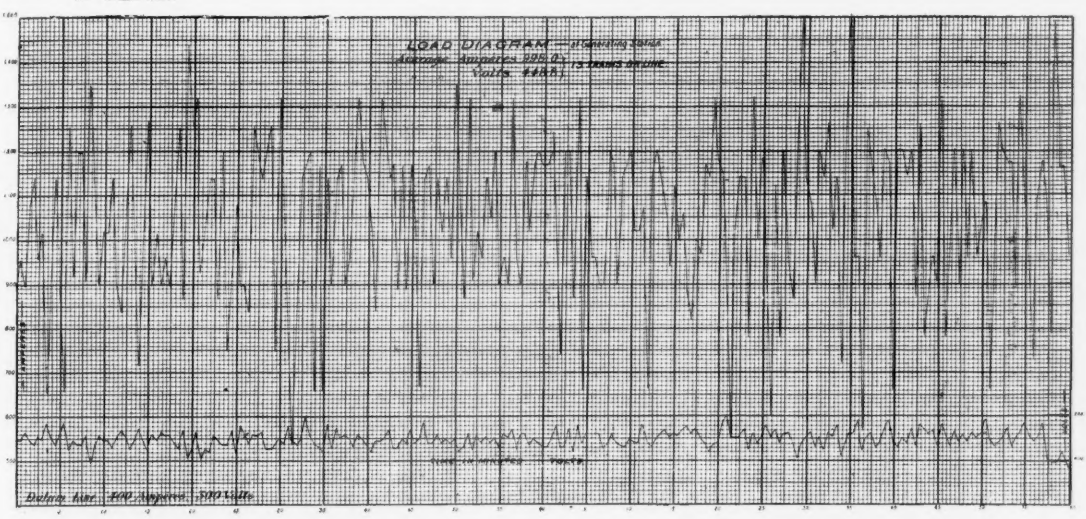
The two new engines are Corliss valve engines, each of the horizontal surface condensing type, having cylinders 15½ inches, 31 inches × 3 feet stroke, each intended to give 400 I.H.P. as an economical load when running at 100 revolutions per minute, with a boiler pressure of 120 lbs. per square inch. The engines are of ample proportions throughout, and are fitted with a steam jacketed receiver between the cylinders containing boiler pressure steam. The beds are of the box type, and of heavy section. The fly-wheels are 14 feet diameter, and are grooved for 19 ropes, each 1¼ inch diameter. The condensing apparatus is a separate plant, having its own air and circulating pumps.

Among other features of the new engines are, first of all, the construction of the cylinders, which are of the four-valve Corliss type,

and which, instead of being cast in one piece, as is usual, are each built up of four principal castings, namely, a working barrel, a jacket, and two end pieces containing the circular steam and exhaust valve chambers, thus substituting four comparatively simple castings, which can each be cast of the mixture most suited to its purpose for a single casting of so complicated a character that it can only be cast of a comparatively soft mixture, and it is even then liable to failure from initial stress aided by unequal expansion. This sub-division not only reduces the chance of disablement, but should such occur the defective part may be replaced with much less expense and delay than a complete cylinder. Both cylinders are thoroughly steam-jacketed, the steam traversing the jackets on its way to the respective cylinders. The governors are rope driven, and are of a new design, especially intended to combine the powerful governor with one of great sensitiveness, for dealing with great variations of load (a diagram is given showing fluctuations in load).

The output of each dynamo is 500 volts, 500 amperes, at a speed of 420 revolutions per minute.

The armatures are so arranged as to be interchangeable, identical in the matter of external dimensions with the existing ones, the resistance from brush to brush measures ·010 ohms. The magnets, however, instead of being of the double horse-shoe type as in the present machines, are of a single horse-shoe, with the poles at the top. This has resulted in an increase of efficiency, the shunt resistance being now 100 ohms as against 75, making an *electrical efficiency* of 98 per cent. The loss in hysteresis, eddy currents, windage, &c., amounts to 6,000 watts, so that the *commercial efficiency* at full load will be about 95·7 per cent.



The magnets are of special magnetic steel of the highest permeability, and are arranged with the patent hinged pole-pieces. This allows of ready access to the armature for inspection, cleaning, or lifting without the necessity of unsetting the bearings.

The dynamos are rope-driven by 19 1½-inch ropes, the rope pulley running between two bearings, and the pulley shaft being connected to the armature by a coupling, so that the armature can be changed without disturbing the ropes. The bearing at the commutator end of the machine is of the spherical type. The diameter of the shaft through the bearings is 5 inches, the length of each bearing being 1 foot 5 inches.

The bushes are of phosphor bronze lined with white metal, the top brasses of each bearing being slotted to receive *two* lubricating rings, the bottom brass being continuous.

The total weight of the machine is 24½ tons, the armature being 3 tons 2 cwts.; the steel magnet casting alone, without winding, is 12 tons.

The main switchboard consists of six slate panels, with sets of switches and instruments, one set for each dynamo in generating station.

Each panel is fitted with—

One patent double-pole automatic magnetic cut-out, with plate glass shields to protect the attendant from the arc, in case a short circuit on the line causes the cut-out to open with excessive load. These cut-outs are also employed as main dynamo switches, being made and broken by hand for connecting the individual dynamos to the omnibus bars. The magnets of the cut-out are compound wound, so that the circuit is broken immediately in case of a reversal of current.

One single-pole throw-over switch for connecting the dynamo circuit (beyond the automatic cut-out) either to the omnibus bar, which feeds into the central conductor at the nearest point to the generating station, or through a feeder to a distant point on the line to equalise the E.M.F.

One 33-way sliding, regulating switch to vary the resistance in the dynamo shunt circuit for maintaining the E.M.F. of each dynamo constant.

One set of double-pole plugs for connecting voltmeter to dynamo before paralleling.

One "Weston" ammeter, indicating the current passing from each dynamo to the line.

The slate slabs are held on wrought-iron framework, all connections at the back being of heavy cast-bronze rods, supported on pillars, so that all straps and connections are accessible, no insulated cable being employed.

The front of the board is finished off with massive teak carved pillars and panels.

Besides the instruments already described there are four "Weston" voltmeters, with illuminated dials, and an engine room clock supported on panelled framework above the slate slabs. The voltmeters are arranged as follows:—

One connected directly across the omnibus bars.

One for connecting at will to any dynamo by means of plugs to take E.M.F. before paralleling.

One for connecting across brushes of the dynamo running on the feeder circuit.

One as pilot voltmeter connected to the distant point in the line where feeder is coupled.

To meet the increased traffic that is expected from the Southern Extension, new rolling stock is being built by Messrs. Brown, Marshall & Co., and as the number of passengers carried is now over 7½ millions a year, the directors have found it necessary to increase the size of the trains by composing them of three carriages instead of two. In fact, last half year (excluding bank holidays) an average of 60 per cent. of the seating accommodation of the trains was occupied. The new motors built by the Electric Construction Company are very similar to those at present in use, their strength being increased to meet the additional weight of trains. The following table and plate on previous page give particulars:—

Weight of armature ex. wheels. lbs.	Weight magnets and attachments.	Drawbar pull.		Speed with 50 amps.	Max. efficiency.
		With 120 amps.	With 60 amps.		
2,184	6,066	2,030	680	26 M.P.H.	86%

As this new rolling stock will only be a small portion of that owned by the company, it will be necessary to increase the number of carriages in the present trains, but as the first motors were only designed for two carriages, experiments have been made with a train fitted with a new and very ingenious form of roller bearings designed by the Roller Bearing Company. It has been shown by the falling weight test that this train will start at a reduction of more than 80 per cent. in starting effort over a train fitted with ordinary bearings, and therefore the company will be able, by slightly modifying their present motors and adopting roller bearings, to increase the carrying capacity of all their trains by adding an additional carriage.

The engineers for the Southern Extension have been Sir Douglas Fox., M.Inst. C.E., and J. H. Greathead, M.Inst. C.E., and the author has acted as resident engineer, assisted by Mr Norman and Mr. Fright, and the contractors have been Messrs. Pearson and Knowles for the viaduct portion, and Messrs. H. M. Nowell and C. Braddock for the tunnel portion.

The railway has now been working for over 3½ years, and it has proved that working on the Zone system as regards fares, and having only two classes, is the best for railways of its character, the value per passenger being 1·97d., as against 1·75d. on the Metropolitan Railway in London, whose fares are very much higher than on this railway. The Zone system allows an economy of about 25 per cent. on the staff, and as tickets are only used for first class passengers, there is considerable economy in printing.

The maintenance of the line is naturally very heavy, as there is alone over 80 acres of surface to be protected from corrosion, of which 20 acres are painted with an oxide paint and remainder with black varnish, and at the present it is being painted at the rate of once in two years. During this year experiments have been made with a pneumatic painting machine, which blows the paint on, the result being to reduce the cost from 2·25d. per square yard to 1·24d. per square yard, including all materials.

The motors now run an average of 40,000 miles before requiring repairs, in which time they earn over £200, and can be rewound at a cost of £25. The company has at the north end of the line fully equipped workshops, where they carry out all their own repairs.

In the appendix will be found a comparative statement of receipts and expenditure, and dissection of locomotive expenses, and the plate on page 397 gives curve of electrical horse power for one train.

Further detail of the first portion than I have described to you will be found in the publication of the Institution of C.E., Vol. 117, in papers read before the members by Sir Douglas Fox, vice-President, M. Inst. C.E., and Mr. Greathead, M. Inst. C.E., and also by Mr. Thos. Parker.

APPENDIX. HALF-YEARS ENDING JUNE 30TH, 1896 AND 1895.

	Liverpool Overhead Railway.				City and South London Railway.			
	Dec., 1894.	June, 1895.	Dec., 1895.	June, 1896.	Dec., 1894.	June, 1895.	Dec., 1895.	June, 1896.
Value per passenger	d. 1·67	d. 1 92	d. 1 97	d. 1·96	d. 1 66	d. 1 73	d. 1·71	d. 1·72
Expenditure to revenue	66·84 %	66·43 %	59·97 %	63 05 %	60 87 %	61·55 %	59 62 %	60·22 %
Loco. expenditure to gross expenditure	24·78 „	24·26 „	26 05 „	22·51 „	39·24 „	37·95 „	38 98 „	36 30 „
Loco. expenditure to gross revenue	16·56 „	16·12 „	15 62 „	14 19 „	23·88 „	23 36 „	23 24 „	21·86 „
Traffic expenditure to gross expenditure	38·88 „	37·54 „	35·33 „	36·05 „	38·70 „	39·13 „	38·69 „	38·91 „
Traffic expenditure to gross revenue	25·99 „	24 94 „	21·19 „	22·73 „	23 56 „	24·09 „	23·07 „	23 43 „
	d.	d.	d.	d.	d.	d.	d.	d.
Expenditure per train mile...	13·10	14·38	14·11	15·10	15·36	16·07	15·45	15 96
Revenue per train mile	19·59	21·65	23·53	23 95	25 24	26·11	25·92	26·30
Loco. expenditure per train mile	3·25	3·49	3 68	3·40	6·03	6·10	6·02	5 75
Number of passengers conveyed	3,641,379	3,4t0,060	3,780,375	3,739,575	3,275,649	3,113,199	3,172,438	3,192,672
Train mileage...	314·472	311 346	321 417	313·010	230·604	224·259	227·350	225 554
Number of stations	16	16	16	16	6	6	6	6
Percentage of train punctuality	95 %	96·8 %	98·4 %	98·3 %	...	...	...	...

July 27th, 1896.

DISSECTION OF COST PER TRAIN MILE.

Half-year ending June 30th, 1896.	Lbs. per train mile.	Lbs. per kilowatt.	Pence per train mile.	Pence per kilowatt.
Train mileage, 313,010 ...	...	...	...	..
Kilos. generated (exclusive of battery charging), 1,343,129	...	...	...	...
Generating station—				
Coal	18·24	4 253	·491	·115
Ashes	...	...	·016	·003
Stores	...	...	·164	·039
Wages	...	...	·763	·176
Repairing department—				
Stores	.	...	·425	·099
Wages	..	...	·321	·074
Drivers' department—				
Wages	...	...	1 220	·287
			3·400	...

DISCUSSION.

Sir DOUGLAS FOX, the President of the Section, in inviting discussion on the paper, remarked how great an improvement the railway was on anything that had been done in America, especially as regarded the construction.

Sir WM. FORWOOD, the Chairman of the Liverpool Overhead Railway, said that he was persuaded that in anything one undertook in connection with electricity, they must have good machinery. He considered that the success which had been achieved on the Overhead Railway was due to the employment of the best machinery they could obtain. There was still, however, great room for improvement of motors, for the costs of repairs were too high. The Overhead Railway had been a great boon to Liverpool, and cheapened the cost of working the Docks. After referring to the low cost per train mile, which were better than could be obtained with separate locomotives, he said that in the last six months 98 per cent. of the trains were punctual; that was a degree of efficiency which had never yet been reached by any other system.

Prof. UNWIN, speaking of the great convenience of the elevated railway in New York, thought considerable advance had been made on it by the Liverpool Overhead Railway, especially in structure. The substitution of electricity for steam on a railway within the town limits was a great change for the better. He was not yet entirely convinced that electricity was suitable for working ordinary railways, but for town railways it was admirably adapted. He asked the author of the paper if he could give the water per indicated horse-power, as well as the weight of the trains?

The AUTHOR, in replying, promised to supply the figures for which Prof. Unwin asked in his abstract for the *Proceedings*.

The PRESIDENT referred to the efforts made by the Overhead Railway Company to provide recreation rooms for the workpeople.

ON A COMPLETE APPARATUS FOR THE STUDY OF THE PROPERTIES OF ELECTRIC WAVES.

By JAGADIS CHUNDER BOSE, M.A. (Cantab.), D.Sc. (Lond.), Professor of Physical Science, Presidency College, Calcutta.

(*Read in Section A, September 21st*, 1896.)

THE work of Hertz and his eminent successors, both here and in the Continent, has opened out for study a new region of ethereal vibration, bridging over the gap that hitherto existed between the comparatively slow electric vibrations and the quick oscillations which give rise to radiant heat. In the vast range of possible ether vibrations we recognise only a few octaves by our senses; the rest are beyond our perception. Many unexpected properties of these little-known ether waves are now being gradually discovered. Confining our attention to the electric waves, we find that there are many important problems which may, perhaps, be better attacked with these comparatively slow ether vibrations; among which may be mentioned the determination of the indices of refraction of various substances which are opaque to visible light, but are transparent to the electric ray; the relation between the dielectric constant and the refractive index when the rates of oscillation are made comparable in the two determinations; the variation of the index with the frequencies of vibration. Then there are the phenomena of double refraction, polarisation, and the magnetic rotation of the electric ray; the determination of the wave length, and other problems of a similar nature.

The fascination of the subject drew me to its study, though the investigations were rendered exceedingly difficult in India from want of facility for making the necessary instruments. I ultimately succeeded in constructing a few instruments with which I was able to obtain the values of the indices of refraction of various substances for electric waves, the wave length of electric radiation, and to demonstrate the phenomena of double refraction and polarisation of the electric rays. The simplified apparatus with which many of the properties of electro-magnetic radiation may be studied is here exhibited. This is a duplicate made by Messrs. Elliott Brothers of the somewhat rudely constructed apparatus which I brought from India. I also take this opportunity of thanking Mr. Bolton, F.R.A.S., of the Mathematical Instrument Department, Calcutta, for the divided circle in my apparatus.

The following are the experiments which may be carried out with this apparatus:—

A.—Verification of the laws of reflection.
  1. Plane mirrors.
  2. Curved mirrors.

B.—Phenomena of refraction.
  1. Prisms.
  2. Total reflection.
  3. Opacity caused by multiple refraction and reflection.
  4. Determination of the indices of refraction.

C.—Selective absorption.
  1. Electrically coloured media.

D.—Phenomena of interference.
  1. Determination of the wave length by curved gratings.

E.—Double refraction and polarisation.
  1. Polarising gratings.
  2. „ crystals.
  3. Double refraction produced by crystals.
  4. „ „ „ other substances
  5. „ „ „ strain.
  6. Circular polarisation.
  7. Magnetic rotation.
  8. Electro-polariscope and polarimeter.

In the list of experiments above-mentioned, the determination of the wave length by curved gratings has been carried out with a larger apparatus (*see* the current number of the *Proceedings*, Royal Society). Experiments with circular polarisation and magnetic rotation are still in progress. All the others have been repeated with the apparatus to be described below.

The complete apparatus consists of—(1) A radiating apparatus emitting electric waves of short length; (2) A receiver used as a detector of electric radiation; and (3) Various accessories for the study of the different phenomena.

Radiating Apparatus.

Electric oscillation is produced by sparking between two beads of platinum and an interposed sphere of the same metal. The discharge ceases to be oscillatory when the ball is roughened, and a platinum ball resists, to a great extent, the disintegrating action of the sparks. Two jointed electrodes carry the two beads at their ends. The distance between the beads and the interposed sphere can thus be adjusted. This is a matter of importance, as the receiver does not properly respond if the spark length is too large. It is more convenient to use short electric waves, and this is obtained by making the radiating spheres very small. The shortest wave length produced is about 6 mm., and the corresponding number of oscillations is about 50,000 millions in a second. The frequency of vibration in this case will be seen to be about 13 octaves lower than that which produces visible radiation. The intensity of radiation in the above case is rather feeble, and I use, in general, electric waves of about half an inch in length.

The jointed electrodes carrying the beads are in connection with a small modified Ruhmkorff's coil, actuated by a small storage cell. The usual vibrating interrupter is a source of trouble; the contact

Fig. 1.—The Radiator.

points get worn out, and the break becomes irregular. I have, therefore, discarded it in favour of a simple interrupting key. The great objection to the continuous production of secondary sparks is the roughening of the surface of the radiating ball, by which the spark ceases to be oscillatory. It is very troublesome to be obliged to take out the radiator, in the middle of an experiment, for polishing. The flash of radiation produced by a single break is enough for an experiment, and it is a mere waste to have a series of useless oscillations. To economise space, I wind the condenser (a long strip of paraffined paper with tin foils on opposite sides) round the secondary of the coil, appropriate connections being made with the interrupting key. The coil and a small storage cell are enclosed in a tinned iron box. Iron is used to screen the space outside from magnetic disturbances due to the making or breaking of primary circuit of the coil. A sudden magnetic variation disturbs the receiver. The iron box is placed inside a second box of thick brass or copper. These precau-

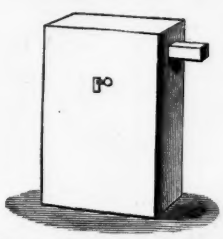


Fig. 2.—The Radiating Box.

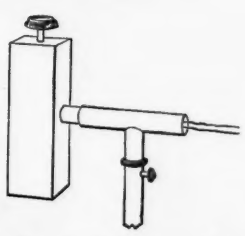


Fig. 3.—The Spiral Spring Receiver.

tions are taken to prevent straying of electric radiation. Through a small opening behind the box, the stud of the press-key projects. In front of the box is the radiator tube, which may be square or cylindrical. Inside this tube is mounted the radiating vibrator. A flash of electric radiation is produced by proper manipulation of the interrupting key. The radiating apparatus may thus be made very small and portable, and requires very little attention. After the storage cell is once charged, experiments may be carried on for days, a flash of radiation being produced at any time by merely manipulating the key.

Spiral Spring Receiver.

The receiving circuit consists of a spiral spring coherer, in series with a voltaic cell and a dead-beat galvanometer. The receiver is made by cutting a narrow groove in a rectangular piece of ebonite, and filling the groove with bits of coiled steel springs arranged side by side in a single layer. The spirals are prevented from falling by a glass slide in front. The spirals are placed between two pieces of brass, of which the upper one is sliding and the lower one fixed. These two pieces are in connection with two projecting metallic rods, which serve as electrodes. An electric current enters along the breadth of the top spiral and leaves by the lowest spiral, having to traverse the intermediate spirals along the numerous points of contact. The resistance of the receiving circuit is thus almost entirely concentrated at the sensitive contact surface, there being little useless short-circuiting by the mass of the conducting layer. When electric radiation is absorbed by the sensitive surface, there is a sudden diminution of the resistance, and the galvanometer spot is violently deflected.

By means of a very fine screw the upper sliding piece can be gently pushed in or out. In this way the spirals may be very gradually compressed, and the resistance of the receiver diminished. The galvanometer spot can thus be easily brought to any convenient position of the scale. When electric radiation falls on the sensitive surface, the spot is deflected. By a slight unscrewing the resistance is increased, and the spot made to return to its old position. The receiver is thus re-sensitised for the next experiment.

The sensitiveness of the receiver may be increased by a proper adjustment of the E.M.F. acting on the receiving circuit. The receiver at each particular adjustment responds best to a definite range of vibration lying within about an octave. The same receiver could, however, be made to respond to a different range by an appropriate change of the E.M.F.; careful adjustment of this is necessary to make the receiver respond at its best to a particular range of electric vibration. For simple experiments, the adjustment of the receiver is not difficult, but for delicate experiments very careful manipulation is necessary.

The proper adjustment of the E.M.F. is effected by taking a derived current from a circular potentiometer slide, fixed at the base of the galvanometer. A simpler way is to take a U tube, the two limbs being respectively filled with copper sulphate solution and dilute sulphuric acid. Mixture of the two solutions is prevented by an interposed plug of asbestos. A rod of copper and a rod of zinc are plunged in the two electrolytes, the whole forming a modified Daniell cell. The cell is shunted by a suitable resistance, the receiving circuit being connected to the ends of the shunt. The current flowing through the shunt, and therefore the derived E.M.F. from its ends, is varied by plunging the rods more or less in the solutions.

The leading wires from the ends of the receiver are enclosed in layers of tin-foil; the galvanometer and cell have a metallic cover with a slit for the passage of reflected spot of light. The receiving circuit is thus shielded from the disturbing action due to stray radiations.

The receiver is provided with a *collecting funnel*. This prevents lateral waves from acting on the receiver. The funnel has two hinged side doors by which its area—and, therefore, the amount of radiation collected—may be varied. When angular deviation is to be measured, the doors are made parallel and perpendicular to the layer of spirals. The aperture is reduced, and the receiver then only responds when the funnel points to the direction of the deviated ray.

In polarisation experiments, it is necessary to adjust the receiver carrying the analyser in a crossed position. This is done by a tangent screw, the rotation of the analyser being measured by means of an index and a graduated vertical disc.

(To be continued.)

INCANDESCENT LAMP TESTS.

The long-expected paper by Mr. W. H. Preece has been given to the public at last, and a very interesting paper it is. One always expects to find something new in a paper by Mr. Preece; new, that is, in detail, for one merit his investigations possess are that they deal with matters of practical interest. Our columns have borne witness to the many attempts that have been made to answer the oft-repeated question, "Which is the best lamp for me to use?" Although the reply must necessarily be that there is no best unless the conditions of use be defined, there is yet a hankering after more definite information that has been, so far, published. From the time of the Philadelphia Exhibition, when a committee of the Franklin Institute made an examination of lamps then in existence in a way which was considered "more complete and thorough than anything which had hitherto appeared on the subject" (Electrical Review, September 12th, 1885), test after test has been taken, culminating with the much talked-of Paisley trials last year, and one or two since.

Life tests of lamps are readily made; many consumers make them for themselves by noting the date of starting a new lamp on the plaster in the socket and keeping a record of the estimated hours each lamp has lasted. Photometric trials are not so easy; first of all the necessary apparatus must be at hand, and then the observer requires to have some knowledge of how to go to work. For the latter reason, a well-known name carries more weight than one which is not often before the public. But the important matter is whether any real progress has been made in methods of testing or the estimating of results.

To our minds, the best thing in Mr. Preece's investigations is the practical method by which he "ages" a lamp,

and by stressing it for something like a couple of minutes to nearly twice its working pressure, he obtains some idea as to its quality and probable life. The Post Office test for India-rubber is based upon an analogous principle, which has been recognised as a good one by the Board of Trade in their insistance upon stressing tests of an hour duration for central station plant. Incandescent lamps may now be tested for: (*a*) efficiency; (*b*) life; (*c*) breaking-up pressure; (*d*) results after stressing to three-fourths of their mean breaking pressure. The latter two tests are comparatively novel, and seem for the first time to have been entered upon systematically.

The life history of lamps—including, as it does, the results of a gradual deterioration in the light-giving filament—seems to establish a falling off of candle-power coincident with a rise in the watts per C.P. Some lamps, as has been shown by Prof. Ayrton, and corroborated by Mr. Preece, show an increase of candle-power at first, afterwards diminishing to the original value, and then falling below it. The average consumer requires a lamp that has a fairly flat C.P. curve until the filament gives way; otherwise, as time goes on, there are sure to be complaints about the supply. Of equal importance is the efficiency; this must be fair, or the cost of lighting is found to be a great objection; but high efficiency has, so far, not proved altogether a success. Mr. Preece says "the so-called high efficiency or economical lamps evidently suffered more than those of about $3\frac{3}{4}$ watts per candle" in the life tests. This corresponds with actual experience on a large scale, and we have frequently pointed out that the demand indicators on consumers' premises usually read as if a 16 C.P. 100-volt lamp took 0·6 to 0·66 ampere, while the 8 C.P. lamp gives nearly 10 C.P. on the average, and certainly is not overrated if taken as a 35-watt lamp. Mr. Preece's figures for current show a rather better result in this respect.

The breaking down test and stressing test will probably be largely used by lamp buyers in time to come. Lamps of 100 volts put on a 200 volt circuit frequently go at once, so it is evident that the test requires care in its carrying out. Lamps of 16 C.P. run, say, in an engine room where the pressure is raised 10 per cent. above the normal at the time of heavy load, each evening, do not last very long, 100 to 150 hours being the average. On the other hand, the curious fact has been noticed that high candle-power lamps (such as 200 C.P. and 300 C.P.) last 700 or 800 hours under the same conditions, but with excessive blackening. What lamp-makers think is manifested by the statement in the recently-issued catalogue of the Ediswan Company that "lamps marked 100 volts are not intended to be run systematically at 102 volts. After all, the pressure variations on a London central station circuit frequently amount to 4 or 5 volts every evening at points close to the generating stations or feeding centres, and lamps are bought to be used with the public supply as it is, not as it should be. The life of $3\frac{1}{2}$ to 4 watts per C.P. lamps may be taken as twice that of high efficiency lamps, and Mr. Preece's figures substantiate that while "a short life and a merry one" is a good adage, if not carried to extremes, we are yet without a satisfactory high efficiency lamp.

Two matters remain to be noticed. The first of these is the formula given in the paper by which the cost per candle power hour can be ascertained. As it stands, it will do good service in removing once for all the impression that arithmetical jumbles of the kind we had to criticise about a year ago (and with which Mr. Howell also found fault) are in any way useful. Here the cost of the lamp per candle-hour is added to the watt-hours per candle hour, multiplied by the price charged per unit (which, by-the-bye, would be more appropriately indicated by B.O.T. than by B.T.U.). The tables calculated from this formula and the results of the tests prove that, if we take 6d. per unit as about the average selling price per unit throughout Great Britain, there is nothing to choose between lamps with efficiencies of 2 to 3 or of 3 to 4 watts per candle, the cost per C.P. hour being about $\frac{1}{40}$th of a penny in each case. With over 4 watts per C.P. and a life of 800 (instead of 400 hours, which we took above as the mean result), the cost rises to $\frac{1}{33}$rd of a penny or thereabouts, showing that the medium efficiency lamp with a fair life is better than one with one extreme virtue and lacking the other.

Lastly, the Post Office specification for lamps is by no means the least interesting of the many good things Mr. Preece embodies in his paper. Here in a readily understood form we find the result of the results of all these tests. What, we wonder, do lamp makers think of it? Perhaps some of these gentlemen may have a few words to offer; if they do not then we may assume, in the pose of a noted character, that they "say nuffin but think all the more." We have seen a good many specifications for lamps, but none have so directly stated what was required as this does. It asks for certain qualities, the possibility of obtaining the same having been demonstrated by experiment. Nichols, Ayrton, Thomas, Merritt, and others, have tested lamps thoroughly, but we have yet to learn that on their results buyers have prepared a specification. Anyhow, until something better appears, we shall be inclined to regard the P.O. lamp tests as a standard.

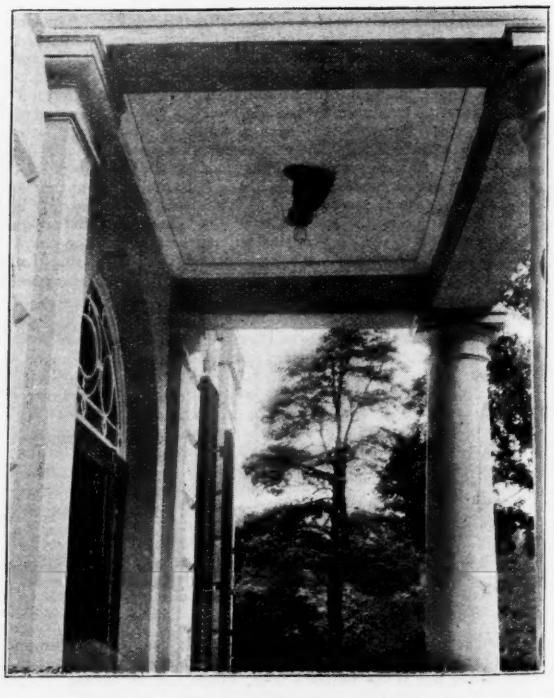
One thing Mr. Preece has kindly left to others to achieve fame in the doing, and that is, to give the profession equally reliable and complete data as to 200 and 220-volt lamps. These have yet to be passed through the mill, and their idiosyncrasies made plain.

CORRESPONDENCE.

Oh! Swallow, Swallow!

Enclosed you will find a photograph of a rather interesting and curious use of an electric lamp holder. As you will see, some swallows have taken advantage of the protection offered by the porch to build their nest round the lamp-holder.

The holder has been in the position for 5 years, and this year the house was redecorated, and in consequence the numerous nests round the eaves of the house were pulled down, and this is the only reason I can give for their having chosen this rather novel building spot.



The place, I might add, is the porch of the front door of my father's house, about 10 miles south of Bristol. The turning on and off of the light does not affect the swallows in the least degree.

If you should care to make use of this in your most valuable paper I am sure I shall be only too pleased.

Frank Armstrong.

Lamp Earnings.

I have to thank you for the notice which you have so kindly given of the Pontypool Station in your issue of September 11th.

I do not know whether the smallness of the lamp earnings

attracted your notice, and as this is a question which is coming steadily to the front owing to the increased amount of competition electric supply stations will have to meet, due to the improvements taking place in the methods of using gas for illuminating purposes, it becomes a very important factor indeed to know how far the revenue per lamp can be decreased and yet maintain the supply on a profitable basis.

The following Table extracted from the figures furnished by the Board of Trade Returns will doubtless be of interest to a great number of your readers. I have cited three South Wales towns because here the works' costs should be approximately equal owing to the price of coal being very much the same and the habits of the consumers very much of the same character, and I have cited the larger stations as showing how the increased output enables the profits per lamp to be considerably increased.

You will note from this table that the lamp earnings at Pontypool are practically 50 per cent. less than the lamp earnings of any of the other towns in the group, but even under these onerous conditions the amount of profit earned per lamp is respectable.

	Newport.	Cardiff.	Pontypool.	Leeds.	Westminster.
Lamp earnings... ...	7s. 10d.	9s. 2d.	5s.	8s.	7s. 2d.
Gross Profit	£224	– £65 loss.	£310	£6,780	£41,324
No. of lamps fixed ...	7,278	9,330	3,238	32,539	210,982
Profit per lamp... ...	7·52d.	–1·67d. loss.	22·9d.	50d.	47d.
Percentage profit to Revenue... ...	8%	nil.	38·2 %	52 %	51 %

Jno. C. Howell.

Dynamo Patents.

Re Mr. Kennedy's letter it may be interesting to know that shortly after Mr. Sayers read his paper before the Institution of Electrical Engineers on the "Prevention and Control of Sparking," &c., I devised a machine, similar to Mr. Kennedy's, with the addition of the "Sayer's" winding, which I still think would work well.

Archibald H. Finlay.

Holywood, County Down.

Electrolysed Sea Water.

I read in the issue of the 4th inst. of your excellent Review an article concerning my communication to the Academy of Medicine of Paris, relating to a new antiseptic obtained by the electrolysis of sea-water. I cannot understand why you head your article "Electrozone." I am not aware of the existence of such a product, and my report relates exclusively to electrolysed sea-water called "Hermitine," from the name of its inventor, M. Hermite; and I should be much obliged if you will publish my letter in order to avoid any mistake.

Dr. Julius Proger.

Paris, *Sept.* 19th.

Workhouse Lighting.

Would you oblige by inviting through your columns anyone who could give information as to any workhouse or other similar establishment which has been or is about to be lighted by electricity to communicate with me.

My Board is considering the subject, and would much esteem any particulars furnished to them which might be of assistance.

Chas. Taylor.

Clerk to the Guardians (Isle of Thanet Union).

Minster, Ramsgate, *Sept.* 18*th*, 1896.

[There are numerous workhouse installations, and perhaps the officials running these could give information. But we think the safest and the proper course is to take the advice of a consulting electrical engineer.—Eds. Elec. Rev.]

Lock Armour for Electric Light Cables.

We have read with interest the letter from Mr. Callender referring to our high-conductivity lock-armoured electric cables. We see that he gives you notice that this is an infringement of certain patents issued to Messrs. Latch and Batchelor as far back as 1884. We may say that these patents refer to matters with which we are not concerned, and that they do not affect the novelty of our new electric cables. If Messrs. Callender & Co. consider that they can prevent our manufacturing and selling our armouring we shall be willing to meet them at the proper time in the Law Courts, where the question can be settled by the proper authorities. Meanwhile, we shall continue to advertise, vend, sell and use our new electric cables; and we desire through your columns to inform our friends that we are perfectly prepared to protect them against any action that Messrs. Callender & Co., or others, may think proper to take.

We would also like to thank Mr. Callender for his letter to you, for we very much appreciate his kindness in calling the attention of the trade to our manufactures.

W. T. Glover & Co.

The Submarine Telegraph Memorial.

Your article in the current number of the Electrical Review relating to the pioneer work of submarine telegraphy will doubtless be read with great interest, more especially by those connected with this important branch of electrical science.

I think, however, to render your article more complete, the fact should be mentioned that the gutta percha cores used in *all* the cables you refer to were made at the Gutta Percha Works of the Telegraph Construction and Maintenance Company, Limited, in Wharf Road, City Road.

These works were started by the Gutta Percha Company in May, 1846, for the purpose of cleansing and utilising the then newly-discovered gum, and in 1864 the company was amalgamated with Messrs. Glass, Elliot and Company, of Greenwich, forming the Telegraph Construction and Maintenance Company, Limited.

As you will see from the date of the formation of the Gutta Percha Company, this is the jubilee of the commercial manufacture of gutta percha, and it may interest your readers to know that during these fifty years we have manufactured, for submarine cables alone, over 140,000 nautical miles of gutta percha covered core.

Willoughby T. Smith.

Gutta Percha Company,
Sept. 21*st*., 1896.

BUSINESS NOTICES, &c.

Aluminium Solder.—A solder for aluminium is, after severe and careful tests, being used by Messrs. F. Braby & Co., of Euston Road, who do not sell the solder but will undertake to do soldering work. This firm finds that the solder will not only hold but will make a strong, bright, clean and neat joint, and they consider it far superior to any other solder yet discovered for aluminium.

Fowler-Waring Cables Company, Limited.—In regard to the paragraph which we published last week, the secretary of this company (Mr. J. A. Blackwood), writes as follows:—"My attention has just been called to a note in your issue of the 18th inst. regarding the final meeting of the shareholders of the old Fowler-Waring Cables Company, Limited, to pass the liquidator's balance-sheet. This is unfortunately likely to mislead many of our clients. The old Fowler-Waring Cables Company, Limited, went into voluntary liquidation in January of the present year, and a new company of the same name came into being in February. This meeting, therefore, is only for the purpose of passing the accounts of a company which has been out of existence for the past six months. The new company is now, with the assistance of the rubber plant which has lately been laid down, carrying on a much larger business than the old company was ever in a position to undertake in the manufacture of electric cables and mechanical rubber goods of every description."

Holophane Globes.—Messrs. Holophane, Limited, are now settled in their premises at 91—95, Queen Victoria Street, E.C., where they will keep on show globes on their system for general illumination (Blondel & Psaroudaki's patents), which is applicable to all forms of light, including arc and incandescent, electric, incandescent gas and oil lamps. They have also issued an illustrated price list, showing globes of various shapes and styles.

Electrical Wares Exported.

Week Ending Sep. 22nd, 1896.	£	s.
Amsterdam	75	0
Borkum. Teleg. table ...	4,818	0
Boulogne	41	0
Brisbane. Teleg. mtl...	763	0
Buenos Ayres. Teleg. wire	829	0
Calcutta	139	0
Cape Town	490	0
Colombo	21	0
Durban	11	0
„ Teleg. mtl. ...	172	0
East London	738	0
Flushing	6	0
Gibraltar	15	0
Lisbon. Teleph. mtl. ...	112	0
Madras	161	0
Malmo. Teleg. mtl. ...	21	0
Mauritius	29	0
Melbourne	846	0
Nelson. Teleg. mtl. ...	15	0
Passages	49	0
Port Elizabeth	93	0
„ Said	63	0
Rotterdam	28	0
St. Petersburgh	88	0
San Sebastian	33	0
Shanghai	213	0
Singapore	9	0
„ Teleg. mtl....	75	0
Stockholm	339	0
Sydney	1,350	0
„ Teleg. mtl. ...	45	0
Tientsin	45	0
Wellington	1,115	0
Yokohama	8	0
Total	£12,855	0

Week Ending Sep. 22nd, 1895.	£	s.
Algoa Bay	238	0
Amsterdam	96	0
Auckland	25	0
Brussels	482	0
Buenos Ayres	68	0
Cape Town	293	0
Colombo	10	0
Demerara	111	0
Dunkirk	190	0
Madras	40	0
Melbourne	140	0
Port Natal	13	0
„ Teleg. mtl. ...	128	0
Rotterdam. Teleg. cable	30	0
Singapore	24	0
Sydney	228	0
Wellington	182	0
Total	£2,298	0

Foreign Goods Transhipped.

	£	s.
Boston. Teleph. mtl....	278	0
Hong Kong. Teleg. mtl.	82	0
Singapore	50	0
Stockholm. Teleph. mtl.	35	0
Total	£445	0

	£	s.
Ghent	10	0
New York	275	0
Sydney	209	0
	£494	0

Forthcoming Publications.—Mr. Gisbert Kapp has just completed the translation into English of his work "Transformers for Single and Multiphase Currents," and Messrs. Whittaker & Co. will issue the same in a few days. A series of electrical engineering design sheets by the same author is also being issued in England by the same publishers, the latter are to be obtained from the publishers only. The same publishers have in the press an important work upon Central Station Electricity Supply, by Albert Gay, Chief Engineer Islington Central Station, and Mr. C. H. Yeaman, Chief Assistant Engineer at the same station. The work will be included in the specialist series, and will be fully illustrated.

Liquidation Notice.—In the matter of the Wigston Electrical and Engineering Company, Limited, a petition for the winding up of the company (or possibly for an order to continue the voluntary winding up, subject to the supervision of the court), was presented to the court on Sept. 15th by Messrs. Taylor & Hubbard, engineers, of Kent Street Works, Leicester, and will be heard on October 28th at the Law Courts, Strand, W.C.

McWhirter's Measuring Instruments.—These instruments are being supplied by the Faraday Electrical Engineering Company, Limited, of Govan. A circular sheet before us gives the details of tests carried out by Professor Jamieson. Particulars are given of the waste of power tests at voltages ranging from 80 to 120 volts; temperature tests (readings when hot, after being in circuit for 20 consecutive hours); retentivity tests, showing the behaviour with rising and falling voltages and the effect of reversing the current; also tests of shielding from external magnetic fields. Professor Jamieson sums up his test by reporting that this new shielded voltmeter is less affected by external magnetism "than any other electro-magnetic one" that he has seen. The temperature error he found also negligible, being only ¼ to 1 per cent. at 100 volts after 20 hours in circuit.

Price Lists.—The General Electric Company, Limited, has issued a supplement to their sixth edition telephone catalogue. The first portion of this brochure is devoted to prices, explanatory letterpress and diagrams referring to their general intercommunication system, and to accessories of same, such as cable junction boxes, &c. The special advantage which is claimed for this system over other schemes of intercommunication is that the switch can be left in any position as last used and a call still be received. The second half of the pamphlet is devoted to the "Stanley" telephone, which has been specially brought out for ready connection to existing electric bell lines. Besides the ordinary wall combinations, there is the "Commercial Stanley Set," and a combined hand telephone (transmitter and receiver), in the handle of which is a ringing and speaking key of ingenious construction, enabling the ringing circuit to be switched out, and the speaking circuit in, or *vice versâ*, by a simple compression of the hand. The "Boudoir" and "Library" pattern instruments are specially artistic. The "Stanley" telephone also lends itself to the construction of some very ingenious and compact intercommunication sets. The diagrams have been carefully prepared to present plainly each particular circuit or scheme of intercommunication, and these are further explained by letterpress.

A neat list has just been brought out by the Standard Accumulator Company, of 39, Victoria Street, S.W. One of the specialities consists of a 4 volt pocket accumulator, which can be supplied with non-corrodible terminals and valves which do not spill. Portable hand lamps, bicycle accumulators, special accumulators for use with Röntgen ray apparatus, and similar apparatus are shown. At the end of the pamphlet is given a list of addresses in London and the provinces, where the batteries can be recharged.

ELECTRIC LIGHTING NOTES.

Aberdeen.—On 16th inst. the committees interested met to discuss the advisability of electrically lighting the quays. It is proposed to light six of the quays by means of arc lamps at present, provision being made for the supply of portable arc or incandescent lamps to shipping at the quays when required. There would be beacon lights of 6,000 C.P. placed at the dock entrance and at Regent Bridge. The cost of the works is estimated at £6,750 on the Town Council and £2,586 on the Harbour Board.

Aberystwyth.—Residents in and about Bridge Street are petitioning for the better lighting of the street by means of an electric lamp.

Backbarrow.—The Brush Electric Lighting Company have for some time past been engaged in improving the mill race and the water sluices at Backbarrow Mills, and they are now stated to have taken down the old water wheel, which has hitherto supplied the motive power at the Ultramarine Works, and have just replaced it with a powerful turbine wheel. The work has been carried out by Messrs. Gilbert Gilkes & Co.

Bangor.—The City Council has again reopened the electric lighting question by deciding to apply for a provisional order for lighting the borough, also parts of the parishes of Llandegai and Pentir.

Battersea.—The County of London and Brush Corporation asked the Vestry for the right to lay mains in a portion of Trinity Road, for the purpose of supplying electricity within the area of the Wandsworth electric lighting order. The Vestry refused to entertain the application.

Belfast.—Tenders were invited a few days ago by Messrs. Murphy & Stevenson, Limited, for the supply and erection of electric light installation in their new factory at Dromore, Co. Down, according to the specification prepared by Mr. J. H. Greenhill, M.I.E.E.

Brixton Theatre.—The lighting of the new theatre built at Brixton by Mr. C. P. Dorman has been carried out by Messrs. Pritchetts & Gold, the generating plant consisting of two gas engines and two Siemens dynamos. There are 994 incandescent lamps inside the building, and four arcs outside. The switchboard is by Dorman & Smith, and the fittings were designed and manufactured by Wilcockson & Co. The wiring and fitting has been excellently done by Mr. J. A. Sayers, representing the contractors.

Bolton.—The Bolton Corporation have decided to apply to the Local Government Board for power to borrow a further sum of £30,000 for electric lighting purposes. At the last meeting of the Gas and Electric Lighting Committee, Mr. Ellis, the chief engineer, submitted an estimate showing that £25,380 would be required to provide the additional buildings, boilers, engines, switchboard, mains, meters, &c. The present works and plant cost £44,620, or £4,260 in excess of the amount sanctioned by the Local Government Board, and to cover this and the extensions now contemplated, £30,000 is required. This will bring the capital outlay upon the works to £70,000.

Cardiff.—Mr. Hallett has reported upon the condition of the plant at the electric lighting station, and made several recommendations. Mr. Appelbee has also reported upon what he considered to be sources of weakness in the generating station and the mains. The whole question was referred to a sub-committee. Mr. Appelbee submitted three schemes for the extension of the electric mains to Cathedral Road. The first, which would cost about £1,600, was adopted. Mr. Appelbee's position was also referred to a sub-committee, with instructions to report.

Cheltenham.—The positions of the 58 arc lamps have been approved by the Council. Alderman Norman reports an increase in the number of lamps connected and applied for from 5,500 8-C.P. lamps, as stated in the last report, to 11,050 at the present time. The number of customers connected was 117, and 18 waiting.

Combe Down (Bath).—At a recent parish meeting the lighting question was considered. One speaker stated that it was probable that some attempt would be made during the next six months to form a company to undertake the electric lighting of the Down.

Country House Lighting.—Mr. Jeremiah Coleman, J.P., is having his mansion at Gatton Park lighted by electricity.

Dover.—The residents in Biggin Street and Cannon Street are memorialising the Town Council, requesting a supply of electricity in their thoroughfares.

Fareham.—The Local Government Board has not yet sanctioned the required loan for the purchase of the electric light undertaking, and the Council is kicking against the delay.

Folkestone.—The report of Dr. Hopkinson *re* the draft agreement with Mr. Hopkins in the matter of electric lighting, has been referred to a committee of the whole Council.

Hoylake.—Application is to be made for a provisional electric lighting order by the District Council.

Huddersfield.—The chairman of the Electric Lighting Committee states that for the half-year ended June 30th last, there had been a deficiency in revenue of £116 11s. 9d., as compared with £624 0s. 11d. in the corresponding half of last year. The Committee is considering whether to wire consumers' premises.

Hull.—The Electric Light Committee has decided to request the chairman, deputy chairman, and the electrical engineer, to appoint one of four applicants to report upon the proposed extension scheme.

Leatherhead.—There was a discussion at the District Council last week *re* a notice of motion to apply for a provisional order, but nothing particular resulted.

Limerick.—As several private firms have laid down their own electric light installations, the Corporation thought it was necessary to apply for a provisional order on that account. The Board of Trade, in reply to a query stated that they were unaware of any Act of Parliament prohibiting private firms from supplying electric light to their own premises or the premises of their neighbours without first having obtained a provisional order under the Electric Lighting Acts, or without the consent of the local authority, provided that the installation was entirely enclosed within the building or buildings, and that it did not cross or interfere with any public road or street. On receipt of this information the Corporation wrote to Prof. Kennedy requesting him not to proceed further with the plans for a municipal installation. The matter is therefore shelved.

Moss Side.—The District Council has been considering the electric lighting question, and thinks a supply might be got from Manchester upon reasonable terms. It is, however, thought advisable to apply for a provisional order, and arrange with Manchester afterwards. A special meeting will consider the matter next month.

Preston.—The street electric lighting is being extended. Lamps are being put up in several thoroughfares.

Simla.—It is stated by an Indian exchange that out of 11 firms who applied to the Municipality for full particulars relating to this electric lighting scheme, only two have submitted tenders to light the town by electricity. Neither of these tenders has yet been accepted.

Southampton.—The question of electrically lighting the municipal offices is under consideration.

St. Pancras.—The Electricity Committee has reported upon the recent failure of the public lighting in Hampstead Road, High Street, Camden Town, and Camden Road. The breakdown seems to have been due to the faulty condition of certain of the cables, which resulted in fusion, and consequently interrupted a number of circuits northward. The chief electrical engineer has considered the question of coupling the lamps to the low tension supply as a temporary means of maintaining the lighting, in the event of accidents, and he estimates the cost at about £270. He had also recommended further alterations, which the committee will report later. It was stated at the last vestry meeting that the committee would shortly have to ask the vestry for the necessary funds to overhaul and rearrange the mains. After a lengthy discussion, it was decided for the present to refer the proposals for temporary measures back for further consideration.

Theatre Lighting.—The Comedy Theatre is being fitted up for electric lighting.

Walsall.—Mains are to be extended in Freer Street. An additional transformer is to be obtained at an estimated cost of £1,000.

Wimbledon.—We hear that the Wimbledon and other authorities in the vicinity have found it desirable to return to the use of oil lamps for street lighting in consequence of the high price of gas. The District Council has, however, resolved to apply again for a provisional electric lighting order.

Windsor.—The electric light installation is progressing, and it is expected that the supply will commence in November. The Royal Albert Brewery is being replaced by a central station. A number of local premises have already been wired.

Workhouse Lighting.—The Thanet Board of Guardians secured three tenders for lighting the workhouse by electricity. They were as follows:—

	Installation.	Annual cost.	Number of lights.
Harrap ...	£1,550	£270	410
Glover ...	£1,484	£200 (No allowance for depreciation.)	383
Mackie ...	£1,130	£287	368

After consideration it was decided to secure information from other Unions where electric lighting was used.

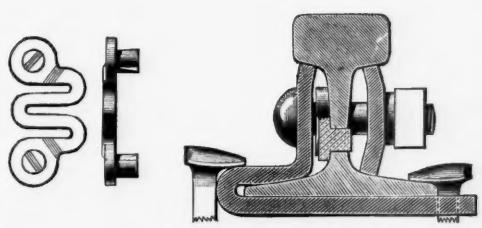
ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Brighton-Rottingdean.—The representatives of the Board of Trade, Majors Marinden and Cardew, have made their inspection of this seashore electric railway. A trial trip was performed on 12th inst.

Glasgow.—There was an exhaustive discussion at a special Corporation meeting on 16th inst., regarding the proposal to send a deputation to America *re* electric traction. Eventually it was decided by 37 votes to 11 that the deputation be sent.

Light Railways.—The Board of Trade has issued rules with respect to the applications to the Light Railway Commissioners for orders authorising light railways.

New Rail Bond.—The present tendency of inventors and manufacturers of rail bonds is towards a short, heavy bond constructed so as to be placed under the angle bar or joint plates. The bond illustrated herewith and known as "Caldwell's self-regulating, self-adjusting 'W' electric bond" belongs to this type. Located under the fishplate it is protected from the weather, vehicles, and from being tampered with maliciously.



It is made, according to the *Street Railway Journal*, in one piece from Lake Superior copper. The terminals or posts, which are made in various sizes and have a wedge-shaped slot in the centre, pass through the rail and are then expanded and made solid by driving in a hard copper wedge or key, no other tool than a couple of hammers being required. The manufacturer claims a contact superior to any other method, and that the bond will adjust itself to all conditions.

The City and South London Railway Extension.—Messrs. J. Mowlem & Co., the contractors for the Waterloo and City Railway, have, according to the *City Press*, undertaken the contract for the construction of the new line from the Monument to Islington for the City and South London Railway, and the work will be proceeded with forthwith. It has not yet been decided what course will be adopted with regard to St. Mary Woolnoth, as it is a question for the engineers as to whether it is possible to construct the station under the church.

Walsall.—Messrs. A. Dickinson & Co. recently inquired of the Council whether they would favourably consider a scheme for connecting Walsall and Birmingham, *vid* the Walsall and Birmingham roads and Great Barr by a tramway. The Council has agreed to do so.

TELEGRAPH AND TELEPHONE NOTES.

Telegraphic Interruptions and Repairs:—

Cables.	Down.	Repaired.
Brest-St. Pierre (1869, Anglo)	April 6th, 1895 ...	...
Puerto Plata-Martinique ...	Dec. 19th, 1895 ...	...
Monte Alegre-Santarem ...	May 5th, 1896 ...	...
Pará-Maranham	Aug. 6th, 1896 ...	Sept. 21st, 1896.
Bahia-Rio de Janeiro ...	Sept. 4th, 1896 ...	...
Penang-Medan	Sept. 7th, 1896 ...	...
Loanda-Benguela	Sept. 13th, 1896 ...	...
Zanzibar-Mombassa	Sept. 23rd, 1896 ...	...
Landlines.		
Trans-Continental line beyond Mazol (Mashonaland)	March 12th, 1896 ...	...
Carthagena - Barranquilla (Columbia)	July 4th, 1896 ...	...
Siberian lines, Habarowsk-Vladivostock	Sept. 16th, 1896 ...	Sept. 17th, 1896
Siberian lines near Krosnoiarsk	Sept. 21st, 1896 ...	...
Mokkha-Hodeida ...	Sept. 19th, 1896 ...	Sept. 19th, 1896

Trunk Lines in Scotland.—The Post Office authorities, on 19th inst., took over the working of the trunk telephone lines in Scotland.

Telegraph Communication with Australia.—The following extract from a New South Wales journal gives an idea of the inconvenience caused to business men by the interruption to the telegraph line. The particular case referred to occurred about the beginning of last month:—"Business men in the city yesterday were lamenting the 'cut-off' in the cable service with Europe. 'It paralyses business,' said one, 'and it is about time we had an alternative route across the Pacific.' Asking as to the effect at some of the principal offices, the answer was, 'We are doing nothing! You know the cable is so closely interwoven with our operations that we practically are at a standstill when a thing like this happens.' Of course, replies to messages have not been received at this end and *vice versâ*. That a flood between Madras and Bombay by washing away a certain number of telegraph posts should so affect the course of business in this country was quoted as an instance of how dependent Australian commerce is upon the existing means of communication with Europe."

CONTRACTS OPEN AND CLOSED.

OPEN.

Belgium.—October 28th. The Société Nationale des Chemins de Fer Vicinaux, in Brussels, is inviting tenders for the conversion of about 23 kilometres of "Vicinal" railways in the Charleroi district, into electric lines on the overhead conductor system. Particulars may be had for 1 fr. from, and tenders to be sent to, the Société Nationale des Chemins de Fer Vicinaux, 26, Rue de la Science, Brussels.

Belgium.—October 21st. The Belgium State Railway authorities have fixed October 21st, as the last date for the receipt of tenders for the supply and erection of all the necessary plant required for a self-contained installation of electric lighting at the railway station at Arlon, for the lighting of the railway station offices, locomotive and waggon shops, locomotive shed, &c. Tenders are to be sent to the Bourse, Brussels, where particulars may be obtained.

France.—October 1st. Tenders are invited for the supply of 594 tons of copper wire and 257,500 porcelain insulators. Tenders to be sent to the Sous-Secretariat d'Etat des Postes et des Telegraphes Rue de Grenelle 103, Paris.

France.—October 8th. Tenders are invited for the supply of 137 kilometres of paper insulated electric cables in 12 lots. Tenders to be sent to the Sous-Secretariat d'Etat des Postes et des Telegraphes, 103, Rue de Grenelle, Paris.

France.—September 26th. Tenders are being invited for the supply and fitting up of pneumatic pipe lines in the French capital. Tenders to be directed to the Sous-Secretariat, d'Etat des Postes et des Telegraphes, Rue de Grenelle 103, Paris.

Italy.—The Italian Naval authorities at Spezia have just invited tenders for the supply of a quantity of miscellaneous electrical fittings.

Madras.—Nov. 11th. Lieut. Col. C. C. Rawson (in charge Consulting Architects' Division) invites tenders for the lighting by electricity of Government House, Madras, including the banqueting hall and the A.D.C.'s bungalow: also for the lighting of Government House, Guindy, including the Military Secretary's bungalow. Particulars to be obtained on application to the Consulting Architect to the Government of Madras, Chepauk, Madras.

Madrid.—October 8th. The Secretary of State for Foreign Affairs learns from her Majesty's Ambassador at Madrid that the Spanish Government have invited tenders for the construction and working of a telephone system in Mayagüez in Porto Rico. October 8th is the date fixed for the consideration of tenders, and such particulars as her Majesty's Government have received may be inspected at the Commercial Department of the Foreign Office between the hours of 11 and 6 daily.

Morley.—October 14th. From our "Official Notices" particulars may be obtained of boilers, engines, dynamos, alternators, &c., for which the Electric Light Committee invites tenders.

South Africa.—October 1st. The Municipal Authorities of Bloemfontein are inviting tenders for supplying and laying down a complete electric lighting installation for the town. Tenderers are to submit a complete description, with plans and specifications, of their proposed scheme to W. A. Koller, Town Clerk, Bloemfontein, Orange Free State.

Spain.—October 12th. Tenders are being invited by the Spanish Post and Telegraph authorities in Madrid for the supply of 60,000 porcelain insulators. Tenders to be addressed to the Direccion General de Correos y Telegrafos, Madrid.

CLOSED.

Spain.—The concession, tenders for which were lately invited, for the electric lighting of the public streets of Merida (Badajoz province) has been granted to Messrs. Martinez, Soriano and Co.

NOTES.

Electric Haulage in Mining.—Electric haulage plant was installed during the years 1893-94 at the Cleveland Lake mine, at Ishpeming, the great lateral extent of the ore body having made necessary some system of mechanical haulage. The generating machinery is located in the engine-house, and consists of a direct current machine of the multipolar type; it makes 650 revolutions; gives an electromotive force of 220 volts without load, and has a capacity of 420 amperes. Two main wires, No. 0 copper, take the current down the shaft, one wire for each level, and are insulated with rubber inside of lead pipe, which is covered with asphalt paint. In the levels the wires are held by the usual mining insulators, at a height of 6 feet 6 inches above the rails. The haulage plant on the first level consists of a 65-H.P. motor machine on four 24-inch wheels, and 20 iron tramcars. On the second level the motor is smaller and of higher speed; it is 30 H.P., on four 30-inch wheels; the cars are of iron, stiffened with wood. With this plant, says Mr. J. E. Jopling, the cost of tramming ore, including the proportion of engine-house expenses and maintenance, and the wages paid to motormen and chute men has been as follows: In 1894, 3·9c. per ton; in 1895, 4·5c. per ton; in 1896, to August 1st, 4·8c. per ton.

Portable Electric Rail Sawing Machine.—The *Scientific American* describes an electric saw, which is used to cut off the battered ends of rails so that they can be relaid, thus obviating the purchase of new rails. The car holding the machine is 12 feet in length × 8 feet wide. The car is equipped with two Rae motors of 30 horse-power each, the current being obtained from a trolley pole. The motors are belted to the saw shaft, and an idler pulley keeps the belts tight. The saw, which is a smooth steel disc, is 42 inches in diameter, makes 1,800 revolutions per minute, and is supplied with water from a barrel by means of small jets. Arrangements are provided for feeding the rail to the saw. In operation this machine has been found to be very efficient and economical, sawing off the end of a 66½-lb. girder rail in one minute. The total cost of sawing rails is $1.50 per ton, which includes the handling of the rails. This machine is used by the Consolidated Street Railway Company of Grand Rapids, Mich.

Telegraph Engineering Appointments.—Mr. Alexander Davidson has recently been appointed as an electrician and cable engineer to the Central and South American Telegraph Company with headquarters at Lima. Mr. Andrew Gray has been promoted to be chief, and Mr. Chas. B. Cruickshank to be second electrician of the West India and Panama Telegraph Company's ss. *Grappler*. All of these gentlemen were distinguished students, and Sir John Pender gold medalists, in the electrical engineering laboratories of the Glasgow and West of Scotland Technical College under Prof. Jamieson.

Coast Communication.—It is expected that the final report of the Royal Commission on Electrical Communication with Lighthouses and Light-vessels—of which body Lord Mount-Edgcumbe is chairman—will be presented before the end of the year. The latest experiments are understood to have proved distinctly encouraging, the system of communication by induction especially having yielded excellent results.

One or 200?—A *Daily Mail* representative interviewed Mr. Radcliffe Ward on the subject of "Electric Omnibuses," and when asked, "How many vehicles do you contemplate running to begin with?" Mr. Ward replied, "About 200 I believe." The statement of Major Flood Page at last Thursday week's meeting showed that not one omnibus is yet completed. Therefore, the day for beginning with 200 vehicles would appear to be just a little distant.

Electro-Harmonic Society.—The programme of this evening's concert, to which we referred in our last issue, will now be found in the Advertisement Supplement of this number.

American Electro-Therapeutics.—The programme of the sixth annual meeting of the American Electro-Therapeutic Association, to be held in Boston, Mass., on September 29th and 30th, and October 1st. The president is Dr. Robert Newman, of New York, and he will take for the subject of his address, "The Want of Education in Electro-Therapeutics in Medical Colleges." The following reports of committees and papers are to be read:—

On Induction Coils and Alternators.
Mr. A. E. Kennelly, Philadelphia, Pa.
On Meters. Dr. M. A. Cleaves, New York City.
On Static Machines and Condensers.
Dr. W. J. Morton, New York City.
On Constant Current Generators and Controllers.
Dr. W. J. Herdman, Ann Arbor, Mich.
On Electrodes. Dr. C. R. Dickson, Toronto, Canada.
On Electric Light Apparatus for Diagnosis and Therapy.
Dr. J. H. Kellogg, Battle Creek, Mich.
What can be done by means of the use of Electricity to avoid Surgical Operations? Dr. G. Betton Massey, Philadelphia, Pa.
Electricity in Chronic Non-Suppurative Affections of the Uterine Appendages. Dr. F. Shavoir, Stamford, Conn.
Discussion by Dr. G. Betton Massey, Philadelphia, Pa.
Electricity in the Treatment of Diseases of the Throat and Nose.
Dr. O. B. Douglass, New York City.
Electricity in the Treatment of Diseases of the Larynx.
Dr. W. C. Phillips, New York City.

Discussion.

Accidents and Risks in the Use of Street Currents. How far are they practicable and safe in the use of Electro-Therapeutics?
Mr. J. J. Carty, E.E., New York City.
Discussion by Mr. John J. Cabot, E.E., Cincinatti, Ohio.
Accidents and Risks in Using Electricity, Generated at Central Stations and Transmitted over Underground and Overhead Wires to Operators in Electro-Therapy.
Danger to Patients and Operators and how Prevented. Also Liability of Physicians using the same.

Digest

Showing the Danger to Patients and Operators, the utter unreliability of Fuse Wires, Resistance Coils and Incandescent Lamps as a Preventative of Excess Flow of Current into Patient. The Liability of and Danger due to the Crossing of Operator's Wire, by Wires carrying High Tension Current, both Direct and Alternating. Mr. John J. Cabot, E E., Cincinatti, Ohio.
Experiments upon the Effects of Direct Electrisation of the Stomach.
Dr. Max Einhorn, New York City.
Electricity in Diseases of the Stomach.
Dr. David D. Stewart, Philadelphia, Pa.
The Static Current in the Post-Apoplectic State.
Dr. John Gerin, Auburn, N.Y.

Lecture I.

The Electrical Principles Generally Used in Medical Treatment.
Prof. William L. Puffer, Boston, Mass.

Lecture II.

The Relations of Physics to Physiology.
Prof. A. E. Dolbear, Tufts College, Mass.
Electro-Therapy in the Treatment of the Nervous.
Dr. W. S. Watson, Fishkill-on-Hudson, N.Y.
The Role of Electricity in the Treatment of Uric Acid Diathesis.
Dr. J. G. Davis, New York City.
Some Observations in Electro-Therapeutics.
Dr. D. R. Brower, Chicago, Ill.
The Physics of the Production of the X Rays.
Mr. Edwin Houston, Ph. D., Philadelphia, Pa.
Mr. A. E. Kennelly, F.R.A.S., Philadelphia, P.A.
Treatment of Strictures by Electrolysis *versus* any other Treatment.
Dr. F. H. Wallace, Boston, Mass.
The Newman Method of Urethral Electrolysis. Its Advantages and Reasons why some Operators fail.
Dr. Francis B. Bishop, Washington, D.C.
Faradism in Gynecology. Dr. R. J. Nunn, Savannah, Ga.

Discussion.

The Motor Dynamo—Adapted to Electro-Therapeutic Work.
Dr. W. J. Herdman, Ann Arbor, Mich.
Discussion by Mr. Edwin W. Hammer, E.E., New York City.
Dr. G. J. Englemann, Boston, Mass.
The Application of Electricity to Surgery.
Dr. J. W. Herdman, Ann Arbor, Mich.
A Summary of the Ultimate Results in 86 Fibroid Tumours, Treated by the Apostoli Method. Dr. G. Betton Massey, Philadelphia, Pa.
Some Experiences and Experiments in the Construction of High Tension Coils and Electrodes.
Dr. Frank W. Ross, A.M., Elmira, N.Y.
Electricity Considered in its Relation to Surgical Gynecology.
Dr. O. S. Phelps, New York City.
A Clinical Report of a Case of Rectal Phlebitis Treated with Galvanism. Dr. D. B. D. Beaver, Reading, Pa.
On the Electro-Therapeutics of the Constant Current.
Mr. A. E. Kennelly, F.R.A.S., Philadelphia, Pa.
Title to be Announced. Dr. M. A. Cleaves, New York City.
Title to be announced. Dr. Fred. H. Morse, Melrose, Mass.

Gas v. Electricity.—Sir Frederick Mappin, Chairman of the Sheffield United Gas Light Company, referred, at that company's meeting last week, to the increase in the use of gas engines. He showed that 30 gas engines had been fixed during the half-year, against 20 in the same period of 1895. Regarding the position of the gas, he believed it was progressing in spite of its powerful antagonist, electricity. In 1895, there were 3,274,000,000 cubic feet of gas sold more than in 1894; the capital of various gas undertakings was increased by £1,750,000; and the profit made was equal to 8·1 per cent. upon the capital. "Their antagonist, electricity, was no doubt fairly prospering. The capital invested in electric lighting was £6,470,000. The receipts were £692,000, and the profit, £315,000, was equal to 4·87 on the capital employed. A comparison was made last year of 86 consumers in Nottingham, which owned one of the most modern and best equipped electric works in the kingdom. These consumers had had the electric light laid on, and had used it for a clear year. They had paid for their gas, during the previous year, £3,215. In this year their gas bill was reduced to £2,336, but their electric lighting bill cost them £2,386; or altogether for the year, £4,723. Consequently gas costing £879 was replaced by electricity which cost £2,386. Therefore the estimate they had heard made as to the difference in cost of electricity and gas had been pretty well maintained, and showed that electricity was 2·71 times as dear as gas was."

A Note for Foreign Traders.—With a view to the expansion of our foreign trade, particularly in the Far East, houses who are indisposed, or unable to work those countries for business by means of personal representation on the spot—so often advocated by British consuls abroad and by ourselves—are probably just now distributing their catalogues and price lists through the mails whenever they get hold of a likely name and address. It is a regular system with some firms to hunt out likely addresses in a foreign directory and send English lists broadcast. They deluge the foreign market, and then wonder why the return is so insignificant. Such lists, however, are quite useless to foreigners like the Chinese, Japanese, and the Spaniard. It may happen that the list contains just what the recipient requires, but this he fails to recognise if in any language but his own. Therefore the book is cast aside, and ten chances to one will never be looked at again. On the other hand, had it been translated into the proper language before being sent out, business to the extent of thousands of pounds might have resulted. It is now recommended by one consular official that such lists would show better results were the weights, measures and prices converted into those of the country from which business is sought. This seems a capital idea. It would facilitate matters for the foreigner. It would entail considerable expense, and require a special edition for each country. But if catalogue business is worth doing at all, it is worth doing well, and foreign business, we consider, is worth a little extra effort just now.

The X Rays a Test for Death.—The horror of being buried alive is with many people so great, that they leave instructions for some small mutilation to be inflicted upon them when the breath has apparently left them, so that assurance may be made whether they are really dead or not. But, thanks to the X rays, a Chicago physician has changed all this. He announces, says the *Photographic News*, that those rays will determine positively whether real death has occurred, or whether the patient is in a trance. Dead flesh, he says, offers more resistance to the penetration of the rays than living, and a glance at the radiograph of the person would determine whether it was that of a corpse or not.

Presentation.—Mr. Francis Teague, M.I.E.E., who has left Coatbridge electricity works to take up the position of Burgh electrical engineer at Paisley, was on Friday last presented by the staff and friends at the Coatbridge works with a case of drawing instruments. The assistant engineer, Mr. W. J. Dale, in a felicitous speech, made the presentation.

A Simple Wiring Rule.—The rule, stated by E. P. Roberts in the *Electrical World*, is that for a drop of 10 volts the ampere-feet is equal to the number of circ. mils cross-section of the wire. For other drops this varies as the ratio of such drop to 10. *Example* 1.—300 lamps, each of 110 volts and one-half an ampere, are to be supplied at a distance of 500 feet with a drop of 10 volts. Required, the size of wire. The ampere-feet is equal to $150 \times 2 \times 500 = 150{,}000$. Therefore, the size wire is 150,000 circ. mils. the nearest size B. & S. gauge being No. 000. *Example* 2.—60,000 feet from a power-house it is desired to supply 200 amperes at a drop of 100 volts. The trolley wire is No. 00. Required, the size of feeder. Ampere-feet is equal to $60{,}000 \times 200 = 12{,}000{,}000$ circ. mils for a 10-volt drop. For a 100-volt drop the size would be 1,200,000 circ. mils Deducting the size of the trolley wire, which is No. 00, or 125,000 circ. mils, gives 1,075,000 circ. mils, equivalent practically to two 500 circ. mils feeders. *Example* 3.—A trolley line is provided with two No. 000 wires. It is desired to know how far they will carry 200 amperes with a drop not exceeding 80 volts. Two No. 000 wires have an area of approximately 320,000 circ. mils, which, divided by 200 amperes, gives 1,600 feet for a 10-volt drop. As the drop is, however, 80 volts, multiply by eight and obtain 12,800 feet as the resistance. Wires of size larger than No. 0000 are generally stated in circ. mils. For the benefit of those who are not familiar with the empirical formula of the B. & S. gauge, attention is called to the fact that it is one of geometrical progression, that is, it doubles in cross-section for every three numbers increase in size, and each size has a cross-section ·8 of that of the next larger, and that No. 10 B. & S. is about 10,000 circ. mils. No. 5 B. & S. weighs 100 lbs. per 1,000 feet. The formula would be accurate if the resistance of a mil-foot of commercial copper was 10 ohms at ordinary temperatures, and for standard wire the formula is correct within 5 per cent. In other words, it is more accurate than the data on which the calculations are based. Greater accuracy is unnecessary.

Refuse Disposal.—Some interesting particulars concerning the working of the refuse destructors in Leeds were contained in a paper read before the Sanitary Inspectors' Association. It appears, says the *Mechanical World*, that there are three destructors, each being situated in a different part of the town, in order to avoid the necessity of carting the refuse to a central depôt. In these destructors, which have been in operation for a period of three years, no less than 181,645 tons of refuse have been burned. Excluding the expense incidental to superintendence, the total cost of destroying the refuse, including interest on the capital expenditure, amounted to slightly over 2s. per ton. Of course this sum does not imply a loss, since in many cases it would have cost more than 2s. per ton to cart the material to sites where it would be harmless; and it is just the difference between the actual cost of destruction per ton, and the expense which would have to be incurred in disposing of the refuse other than by combustion, that represents the economy of refuse destructors. With regard to the clinkers, contractors are paid by the Corporation from 4d. to 9½d. per ton, according to the position of the destructor, for removing this material from the depôts. A small quantity of clinker is converted into mortar; but this process does not appear to be profitable, and at one of the depôts the system has been abandoned. The facts thus set forth from the experience gained in the working of the Leeds refuse destructors may be commended to the consideration of those enthusiasts who are always looking for "gold in the dustbin."

Lectures.—At the Regent Street Polytechnic special courses of instruction will be given during the winter in "Experimental Physics and Electrical Engineering," under the direction of Mr. W. Hibbert, assisted by Messrs. Thorrowgood and Sewell. Particulars as to fees, &c., can be obtained from Mr. R. Mitchell, director of education.

Mr. G. R. Peers has commenced a series of lectures on "Electricity" at the Halifax Technical School.

Mr. Robert MacDonald, M.A., B.Sc., lectured at the Belfast Science School on "Electricity" on 14th inst.

At the "Three Cranes Hotel," Barnsley, on 12th inst., Mr. G. H. Groves read a paper on "Electric Haulage as Applied to Mines."

The South-West London Polytechnic Institute.—This Institute, which was only opened last October, has already some 1,400 students. The work hitherto has been mainly in the evening, but on September 29th the Institute will be opened to day students in mathematics, mechanics, mechanism, architecture and building construction, drawing office work, workshops, electrical technology, physics, physical and electrical laboratories, chemistry, chemical laboratory, and applied art. The hours will be from 10 a.m. to 1 p.m., and from 2 p.m., to 5 p.m., on each working day except Saturday, when the hours will be from 10 a.m. to 1 p.m. The student may, for a very moderate fee, go through a complete course of electrical engineering, mechanical engineering, architecture, technical chemistry, applied art, and Colonial training, in two years, provided he can devote his whole daytime to the work. If he cannot do this, the classes are so arranged that he may go through a precisely similar course in three, four, or more years, and as similar courses are provided in the evening, the opportunity is afforded him of shortening the period by attending evening as well as day classes. As stated in the prospectus, the objects of the day classes are:—(1) "To give that preparatory training which will fit students over 15 years of age for practical work in the factory or engineer's shop, or prepare them for Colonial life"; (2) "The Education of pupils from middle class and other schools, who are preparing for a higher technical and scientific course of instruction, such as is provided at the Central Technical College, Exhibition Road." The education will be given partly by lectures and exercise classes, but mainly through the laboratory and workshop practice of the students themselves. The Institute is provided with well-equipped workshops for engineers, smiths, carpenters and joiners, pattern makers, plumbers, masons, plasterers, and painters and house decorators, with laboratories for engineering and mechanics, electrical engineering, physics and chemistry, and with studios for art, photography, and electro-deposition. The building is lighted throughout with incandescent lamps, and the electric lighting plant of the Institute is also available for experimental purposes. The full prospectus is illustrated by well-executed photographic plates of the laboratories and workshops.

Li Chung Tang.—This notable has been well looked after in the States by electrical men, and he talked to them for one whole hour after he had visited the Niagara Falls power plant. He accepted a pair of telephones as a gift, but thought the Chinese Embassy fearfully behind the times for not having improved long-distance instruments in their Washington office, so that he might talk to them from Niagara. "Why, we have lines 60 miles long in Northern China!" said Li. He asked, as usual, many curious questions, and was, apparently, disappointed that no one told him "just what electricity was." So he proceeded to find out for himself, and poked his cane at one of the revolving dynamos. The result, which was instantaneous, has already been recorded in the London daily Press, though with slight variations from the truth. He did not receive a shock, and was not "prostrated for the rest of the day," as the daily Press said, but his cane was knocked from his hand, causing him a little surprise, that is all. The interpreter to the party, in reply to inquiries from the representative of our trans-Atlantic namesake, said that there were no trolley cars in China, very little electric lighting, and some old-style telephones in the port cities, but none in the interior.

Standards of Light.—A sub-committee of the American Institute of Electrical Engineers, appointed in 1893 to investigate the subject of a suitable standard of light for photometric purposes, has recently issued a preliminary report. Of all the standards thus far used it finds the candle the least reliable. It is also evident from the bolometric curves that naked flames are subject to sudden and rapidly recurring fluctuations that may be almost entirely eliminated by the use of a properly constructed chimney. It seems likely, says the *Engineer*, that many of the difficulties which are unavoidable with flame standards may be overcome by the adoption of a standard consisting of some surface electrically heated to a standard temperature. With this object the results of the committee's experiments on incandescent carbon will be looked forward to.

Connecting Incandescent Lamps in Series on Alternating Circuits.—The article on this subject which appeared in our issues of September 4th and 11th, and for which we gave credit to *L'Industrie Electrique* was, we are informed, previously published in the *Elektrotechnische Zeitschrift* of Berlin, and would seem to have been translated from that journal into French, though, as given, it is calculated to lead to the belief that it was an original article specially prepared for the Paris journal.

Penywern College.—The winter session of the Penywern Road Electrical and General Engineering College commences on October 1st. We understand that experimental work of all kinds, including the construction of machines for inventors, is carried out in the college workshops.

Personal.—In our reference last week to Mr. J. Crosland's marriage, we stated in error that that gentleman is manager of the Telegraph Manufacturing Company. That position is held by Mr. Jas. Taylor, and Mr. Crossland is superintendent of the cable manufacturing department.

Motor Cars Prohibited at Buda Pest.—According to a letter in Wednesday's *Times*, the Buda Pest authorities have, after a six months' trial, forbidden the further use of motor cars in the streets there, on account of the many accidents which have occurred. And yet some people say "Why should London wait?"

Long Life.—The Cruto Incandescent Lamp Agency, Limited, have recently been informed that one of their high voltage lamps (210 volt 25 C.P.) ran continuously for upwards of 5,060 hours, the efficiency being maintained with remarkably little diminution during the whole time.

Water Power.—We understand that the Stockton and Middlesbrough Water Board are considering whether they can utilise the motive power from the waterworks for lighting the towns electrically.

NEW COMPANIES REGISTERED.

Kirlew, Brothers, Limited (49,449).—Registered September 18th; capital £5,000 in £1 shares, to acquire, take over as a going concern, and carry on the business of electrical and general engineers, iron and steel merchants, fitters and millwrights, &c., carried on by Gilbert R. Kirlew, trading as Kirlew, Brothers, at 48, Torrington Square, W.C.; and to adopt an agreement with the said vendor. The subscribers (with one share each) are:—G. R. Kirlew, 5, Upper Camp Street, Higher Broughton, merchant; C. R. Broomhead, 5, Upper Camp Street, Higher Broughton, agent; Miss M. Kirlew, 5, Upper Camp Street, Higher Broughton, clerk; J. W. Hamill, M.D., 81, Burynew Road, Higher Broughton; Mrs. R. Kirlew, 5, Upper Camp Street, Higher Broughton; R. L. Kirlew, 48, Torrington Square, W.C., engineer; Mrs. J. Kirlew, 48, Torrington Square, W.C. Registered without articles of association. Registered office, 48, Torrington Square, W.C.

Tyne Cycle Manufacturing Syndicate Limited (49,451).—Registered September 18th; capital £15,000, in £10 shares, to carry on the business of manufacturers of and dealers in cycles, cippedes and auto-cars and carriages, and to buy, sell, hire, let or deal in dynamos, insulating materials, accumulators, and other electrical apparatus. The subscribers (with one share each) are:—J. Liddell, Benwell Hotel, Newcastle, coalowner; J. Walker, 11, Osborn Road, Newcastle, engineer; G. Renwick, 7, Osborn Terrace, Newcastle; T. O. Robson, Low Fill, Gateshead, viewer; D. Davis, Durham Road, Gateshead, manufacturer; E. O. Scorfild, 15, Osborn Terrace, Newcastle, agent; J. S. Eltringham, South Shields, shipowner. The number of directors not to be less than three, nor more than seven. The first are J. Walker, D. Davis and G. Renwick. Qualification £250; remuneration as the company may decide. Registered by Jordan & Son, 120, Chancery Lane. Registered office, 27, Gray Street, Newcastle-on-Tyne.

Electric Lighting Extension Syndicate, Limited (49,462).—Registered September 19th; capital, £5,000 in £1 shares, to carry on at London and elsewhere the business of suppliers of electricity in all its branches, and to purchase, construct, lay down, establish, fix, and maintain all necessary cables, wires, lines, accumulators, lamps, and works. The subscribers (with one share each) are:—J. Hayer, 7, Royal Avenue, Chelsea, S.W., electrical engineer; F. M. Staunton, 2, Hainault Villas, Harold Wood, Romford, electrical engineer; C. O. Bastian, 8A, Manchester Square, W., electrical engineer; P. W. O. Hodges, 30, Hampstead Road, N.W., civil engineer; W. R. Wilson, 110, Long Acre, W.C., brewer; H. C. Hodges, 30, Hampstead Road, N.W., electrical engineer; W. Bastian, 8A, Manchester, W., medical student. The number of directors not to be less than three nor more than five; the subscribers are to appoint the first; qualification, £50; remuneration 1 guinea (1½ guinea for the chairman per board meeting attended). Registered by Morten Cutler and Co., 99, Newgate Street, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Madeira Electric Lighting Company, Limited (46,371).—This company's statutory return has just been filed; 8,719 shares have been taken up out of a capital of £20,000 in £1 shares, and 6,000 are considered as fully paid; £1 per share has been called on the rest, and £1,721 10s. has been paid, leaving £997 10s. unpaid.

The registered office of this concern was, on July 20th, 1896, removed to Town Hall Chambers, 13, Crossley Street, Halifax.

Midland Electric Light and Power Company, Limited (16,166).—This company's annual return was filed on June 16th; 3,139 shares have been taken up out of a capital of £50,000 in £10 shares, and 3,132 are considered as paid; £70 has been paid on the rest.

London Platino-Brazilian Telegraph Company, Limited (12,093).—This company's annual return has just been filed. The capital is £400,000, in £10 shares. 37,548 shares have been taken up, and the full amount has been called and paid.

London Health Electrical Institute, Limited (37,212). This company's annual return has just been filed. 6,007 shares have been taken up out of a capital of £10,000 in £1 shares, and 6,000 are considered as fully paid. £1 per share has been called and paid on the rest.

National Company for the Distribution of Electricity by Secondary Generators, Limited (18,309).—This company's annual return was filed on August 4th. The capital is £500,000, in £10 shares (of which 3,000 are preference); 2,669 preference and 20,000 ordinary have been taken up, and 1,000 preference and all the ordinary are considered as fully-paid; £10 per share has been called on the 1,669 preference, and the same has been paid. In addition, £1,000 has been received in connection with the forfeiture of 100 shares.

Crompton & Co., Limited (27,200).—This company's annual return was filed on September 2nd. The nominal capital is £280,000 in £5 shares (of which 30,000 are preference); 5,928 ordinary and 28,180 preference shares have been taken up, and 4,000 ordinary have been issued as fully paid; £5 per share has been called on the preference and £1 per share on the 1,928 ordinary, and £142,852 has been paid. This sum includes £24 paid in advance of calls.

Omnibus and Tramcar Electric Lighting Company, Limited (39,656).—This company's annual return was filed recently. The capital is £60,000, in £5 shares; seven shares have been taken up, the full amount has been called, and £35 has been paid.

Northwich Electric Supply Company, Limited (46,958).—This company's annual return was filed on July 2nd. Seven shares have been taken up out of a capital of £10,000, in £5 shares, but no calls have been made.

CITY NOTES.

Electric v. Steam Power on the Rand.

A general idea of the great future that lies before electricity in its application to mining work on the Rand, was given to the shareholders in the Rand Central Electric Works, Limited, at the meeting held yesterday at Winchester House by Sir C. Rivers Wilson, G.C.M.G., C.B., the chairman of the company. From what the chairman stated when moving the adoption of the report and accounts for the 15 months ended June 30th last, which are given in abstract in another column, it would seem that if all goes along as satisfactorily as present promises indicate, there are good times in store for the company. The works—the machinery in which, when opened, will have a capacity for supplying 2,100 brake H.P.—are progressing satisfactorily, and it is almost certain that everything will be completed by Messrs. Siemens & Halske, and in working order, some time in November. So great, however, is the desire among mine managers on the Rand to take up a supply of electric power, that contracts have already been entered into for 1,200 H.P., while other contracts are far advanced for 600 H.P. more. There is, therefore, every reason to suppose that by the time the supply commences the whole 2,100 H.P. will have been contracted for. Mine managers say they are ready for a supply as soon as it is available. All the contracts have been taken upon a basis of £45 per H.P., and this, the board consider, will bring a handsome return. The company had entered into a very favourable contract with the Transvaal Coal Trust Company (their landlords for the main station) for the supply of coal and water. Mr. A. Brakhan, a member of the Johannesburg board, was present at the meeting, and made some very hopeful remarks. Formerly, he stated, everything was done by steam, but for small installations electric power had great advan-

tages, and many leading managers on the Rand looked forward to a very good future for this company. He was quite certain that so great would be the demand for the power, that they would have to look to extending the works later on. There was very wide scope for the company. The power would be wanted for other purposes besides mining. The management out there was very efficient, both technically and commercially. Mr. August Barsdorf, a member of the London board, seconded the adoption of the report, and it was carried unanimously. The retiring directors (Messrs. Marker and Zwilgmeyer), and the auditors (Messrs. Price, Waterhouse & Co.), were re-elected, and the usual vote of thanks closed the meeting.

Rockhampton (Australia) Gas and Coke Company, Limited.

The following are extracts from the director's report for the half-year ended June 30th last:—

The gas operations show a profit of £1,694 16s. 1d., which, with the amount brought forward from last half-year, leaves a credit balance of £1,878 8s. 9d. The electrical storage batteries, referred to in the last report, have arrived, and are in operation. The working expenses of the electrical department are somewhat less than the preceding half-year, while the returns are rather larger. The electrical operations show a profit of £279 7s. 2d., which has been appropriated towards the payment of the interest upon the company's debentures, amounting to £300, leaving a difference of £20 12s. 10d., represented in the debit balance of the profit and loss account of this section of the company's business.

Profit and Loss Account.—Electric Light Operations.

For the Half-year ended June 30th, 1896.

Dr.	£	s.	d.
To generating electric current	520	0	2
„ Management, &c.	64	1	6
„ Printing	8	8	0
„ Interest	300	0	0
„ Stationery	11	8	3
„ Insurance	25	12	6
„ Rates and taxes	3	10	6
„ Private arc maintenance...	13	6	1
	£946	7	0

Cr.	£	s.	d.
By Electric current sales	825	4	0
„ Sundries	12	17	8
„ E.L. fitting account	27	10	6
„ Interest	17	10	0
„ Rental on E.L. fittings	42	12	0
„ Balance	20	12	10
	£946	7	0

The balance-sheet shows the following under assets:—

	£	s.	d.
Sundry debtors for gas and electric light	1,793	19	0
Electric light plant	11,009	10	4
„ „ fittings on rental	932	17	0
„ „ „ in stock	1,375	0	11

The reserve fund shows that £434 has been expended on maintenance and improvement of the electric light plant.

Rand Central Electric Works, Limited.

The report of the directors for the fifteen months ended June 30th last, presented to the general meeting held at Winchester House, E.C., yesterday, 24th inst., states that the statutory meeting was held on July 30th, 1895, since when three calls of 5s. each have been made, in order to meet the payments becoming due to the contractors, Messrs. Siemens & Halske, for the erection of the works at Brakpan, and the shipment of plant and materials for the main line and mine installations. During the period under review, £116,306 has been expended in compliance with the obligations under the equipment contract. The directors have been able to place the sums not immediately required on deposit at satisfactory rates. The interest thus earned up to June 30th last amounts to £2,999, as it appears in the balance sheet. The cession of all contracts entered into by Messrs. Siemens & Halske prior to the formation of the company having been duly completed and registered at Pretoria, the fully-paid 25,000 vendors' shares in respect of and in payment for such contracts were issued in April last. The political troubles in the South African Republic during the early part of this year have somewhat hampered negotiations for the supply of electric power. Contracts, however, for amounts aggregating about 1,200 brake horse-power have been practically completed. Other negotiations are in progress, as a result of which the directors anticipate that the remaining available capacity will be placed. The total capacity provided for in the equipment contract is 2,100 brake horse-power. The building operations at Brakpan (Central Station) were commenced about September 1st, 1895, and up to the middle of August, the date of the last report to hand from Mr. N. J. Singels, the general manager, the iron structure for the engine house, as well as buildings and several houses for the staff, were completed. The engine house has already been roofed for the greater part, and about half the walls have been covered with corrugated iron. The foundations for the boiler house and the two first engines were also ready. The branch railway line from the Netherlands Railway to the Central Station is completed, and has already proved to be of good service, especially for the transit of the plant and heavy machinery. About 900 iron poles have been erected for carrying the main wire, which is to run from the Brakpan works to the Paardekraal farm, and the laying of the wires has been commenced at the Brakpan end. The unfortunate labour conditions in the Transvaal during the first few months of this year have necessarily caused some unforseen delay in the erection of the works. Some further delay has arisen owing to a recent railway accident at Boksburg, by which several parts of the machinery in course of transit were damaged, necessitating their replacement from Europe. No efforts, however, are being spared towards completion of the works, and considering the frequent troubles which mining companies at the Witwatersrand experience in connection with the transport of materials, the probable delay in the supply of power by the electric works may be considered as insignificant.

The Halifax and Bermudas Cable Company, Limited.

The seventh annual general meeting of this company was held at 33, Old Broad Street, London, E.C., on Friday last, the 18th inst., when we understand the following report and the accounts were unanimously adopted:—The cable receipts in the past year (ended June 30th, 1896), were £3,339 4s. 5d., as compared with £4,203 7s. 10d. in 1894-5. This decrease is chiefly due to the diminution in shipping messages. The net result of the year is a profit of £492 11s. 10d., as compared with £1,023 9s. 8d. Offers for the sale of debentures to the trustees were invited in December and June last, when £5,300 of debentures were acquired and cancelled at a cost of £4,911 10s. Of the profit of £492 11s. 10d., it has been considered desirable to place £164 to the reduction of the spare cable account. The balance of £328 11s. 10d., and the £5,300 on account of debentures redeemed during the year are applied to the writing down of capital expenditure. The company's cable has, throughout the year, worked with complete efficiency, and its electrical condition continues excellent. Under the articles of association, Mr. C. R. Hosmer and Mr. Joseph Rippon retire on this occasion, and being eligible, offer themselves for re-election. The auditors, Messrs. Gribbon, Holroyd & West retire in accordance with the articles of association, and they offer themselves for re-election.

Electrical Copper Company, Limited.

The statutory general meeting of this company was held on Monday at the offices, 14, Sherborne Lane, E.C., Mr. H. M. Matheson presiding.

The Chairman reported that all the preference shares had been allotted and paid up in full. The patents had all been transferred to the company. There had been applications both from Germany and the United States with reference to their disposing of the patent right, but they preferred to await the results of the works to be erected at Widnes before parting with any of these rights. They had secured suitable land at Widnes for the erection of the works, on a long lease of 999 years. The plans of the works were nearly completed, engines and dynamos had been ordered, and, according to the dates when all the machinery will be delivered, they hoped to be in operation early next year. The experimental works at Paris had been taken over by the company. They are sufficient for the manufacture of commercial samples, and numerous such samples had been made and reported upon by experts both in England and on the Continent. They were all well satisfied with the copper. Numerous tests had been made by Messrs. Kirkaldy and other experts, which had proved the superior strength and quality of the copper made. A complete series of these tests as arranged by Messrs. Kirkaldy is now being carried on, and certificates will be issued which will enable engineers to judge of the suitability of this company's copper for the purposes of their work. They had issued 100,000 preference shares, and they had all been allotted; but there are still 50,000 to issue by-and-by.

The usual vote of thanks closed the meeting.

Eastern Telegraph Company.—The directors announce the payment on October 15th of interest of 3s. per share, less income-tax, being at the rate of 6 per cent. per annum on the preference shares, for the quarter ending 30th inst., and the usual interim dividend of 2s. 6d. per share on the ordinary shares, free of income-tax, in respect of profits for the quarter ended June 30th.

Willans and Robinson, Limited.—The registers of transfers and members will be closed, prior to the ordinary general meeting, until October 7th.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending September 20th, 1896, were £871; week ending September 22nd, 1895, £831; increase, £40; total receipts for half-year 1896, £10,887; corresponding period, 1895, £10,147; increase, £740.

The Liverpool Overhead Railway Company. The receipts for the week ending September 20th, 1896, amounted to £1,214; corresponding week last year, £1,239; decrease, £25.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1893.	1894.	1895.	Closing Quotation, Sept. 16th.	Closing Quotation, Sept. 23rd.	Business done during week ended Sept. 23rd, 1896. Highest.	Lowest.
173,400£	African Direct Teleg., Ltd., 4 % Deb.	100	4 %	4 %	4 %	100 —104	100 —104	...	...
25,000	Amazon Telegraph, Limited, shares...	10	...	...	...	8½— 9½	8½— 9½	...	...
1,012,880£	Anglo-American Teleg., Ltd.	Stock	£2 11s.	£2 2s.	£2 9s.	50 — 53	50 — 53	52	...
2,993,560£	Do. do. 6 % Pref.	Stock	£5 2s.	£4 4s.	£4 18s.	97 — 98	95½ — 96½	97	95⅝
2,993,560£	Do. do. Defd.	Stock	...	...	...	8¾ — 9¼	8¾ — 9¼	...	...
130,000	Brazilian Submarine Teleg., Ltd.	10	6½% §	7 %	...	15½ — 15⅝	15 — 15½	15⅝	15 1/16
75,000£	Do. do. 5 %, Debs., 2nd series, 1906	100	5 %	5 %	5 %	112 —116	112 —116	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 44,000	5	... §	2½%	4 %	3½ — 3⅝	3½ — 3⅝	...	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	160 —170	160 —170	...	...
224,850	Consolidated Telep. Const. and Main., Ltd. ...	10/-	2 % §	1½%	1½%	1/16 — 3/16	1/16 — 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	12½ — 13½	12½ — 13½	13	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	20½ — 21½	20½ — 21½	...	...
12,931	Direct Spanish Teleg., Ltd.	5	4 %	4 %	4 %	3½ — 4½	3½ — 4½	...	...
6,000	Do. do. 10 % Cum. Pref.	5	10 %	10 %	10 %	10 — 10½	10 — 10½	...	...
30,000£	Do. do. 4½ % Debs. Nos. 1 to 6,000 ...	50	...	4½%	4½%	107 —110 %	107 —110%	...	...
60,710	Direct United States Cable, Ltd.	20	2⅝% §	2 %	2½%	9⅝ — 10⅛	9¼ — 9⅝	9⅝	...
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½%	6½%	18 — 18½	18 — 18⅛	18⅜	18
70,000	Do. 6 % Cum. Pref.	10	6 % §	6 %	6	19 — 20	18½ — 19½	19	18¾
102,100£	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	5 %	104 —107	104 —107	...	...
1,297,837£	Do. 4 % Mort. Deb. Stock Red.	Stock	4 %	4 %	4 %	131 —134	131 —134	...	...
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7 %	18 — 18½	18 — 18½	18⅜	18
54,100£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	5 %	100 - 104	100 —104	...	...
194,300£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	5 %	101 —104	101 —104	...	...
320,000£	Do. 4 % Deb. Stock	Stock	4 %	4 %	4 %	130 —133	130 —133	133 ½	...
80,600£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	5 %	101 —105	101 —105	103¾	101½
107,600£	Do. do. do. to bearer, 2,344 to 5,500	100	5 %	5 %	5 %	102 —105	102 —105	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 3,000, red. 1909	100	4 %	4 %	4 %	106 —109	106 —109	...	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	4 %	111 —114 %	111 —114 %	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	4⅜% §	4½%	4½%	11¼ — 11⅜	10⅜ — 11¼	11 5/16	11⅛
180,042	Do. do. 6 % Pref.	10	6 % §	6 %	6 %	18 — 18½	17¾ — 18¼	18⅛	17⅞
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅜%	8⅜%	10 %	24½ — 25½	24 — 25	25	24½
180,000£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	104 —107xd	104 —107	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	10 %	53 — 56	53 — 56	...	...
100,000£	London Platino-Brasilian Teleg., Ltd. 6 % Debs.	100	6 %	6 %	6 %	109 —112 xd	109 —112	...	...
28,000	Montevideo Telephone 6% Pref., Nos. 1 to 28,000... ...	5	4 %	4 %	...	2 — 2½	2 — 2½	...	...
484,597	National Teleph., Ltd., 1 to 484,597	5	5 % §	5 %	5½%	7½ — 7¾	7½ — 7¾	7¾	7½
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	17 — 19	17 — 19	...	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	17 — 19	17 — 19	...	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 119,234	5	5 %	5 %	5 %	6⅞ — 7⅛	6⅞ — 7⅛	...	...
1,100,000£	Do. 3½ % Deb. Stock Red.	Stock	3½%	3½%	3½%	107 —110	107 —110	107½	107½
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	4¼%	5 %	¾ — ⅞	¾ — ⅞	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4 %	108 —111	108 — 111	...	...
11,839	Reuter's Ltd.	8	0 %	*nil*	5 %	7 — 8	7 — 8	...	...
3,381	Submarine Cables Trust	Cert.	...	...	...	140 —145	138 —143	143½	...
58,000	United River Plate Teleph., Ltd.	5	...	3 %	4 %	3½ — 4	3½ — 4	...	...
146,733£	Do. do. 5 % Debs.	Stock	5 %	5 %	5 %	101 —106	101 —106	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	*nil*	*nil*	4 %	5 — 6	5 — 6	...	...
238,300£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	102 —105 xd	102 —105	...	...
30,000	West Coast of America Teleg., Ltd.	10	*nil*	*nil*	*nil*	1 — 2	½ — 1½	⅜	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	8 %	99 — 104	99 —104	...	...
64,248	Western and Brasilian Teleg., Ltd.	15	2½%	3 %	3 %	8⅜ — 9½	8⅜ — 9½	9 1/16	...
33,129	Do. do. do. 5 % Pref. Ord. ...	7½	5 %	5 %	5 %	7 — 7½	6⅞ — 7½	...	...
33,129	Do. do. do. Def. Ord.	7½	...	1 %	1 %	2¼ — 2⅜	2¼ — 2⅜	...	...
165,200£	Do. do. do. 6 % Debs. "A," 1880 Red.	100	6 %	6 %	6 %	103 —107	103 —107	...	...
206,400£	Do. do. do. do "B," do.	100	6 %	6 %	6 %	103 —107	103 —107	106	...
88,321	West India and Panama Teleg., Ltd.	10	⅛%	⅛%	⅛%	1¼ — 1½	1⅜ — 1⅝	1 7/16	1⅜
34,563	Do. do. do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	11½ — 12	11½ — 12	11 13/16	11½
4,669	Do. do. do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	9½ — 10½	9½ — 10½	...	...
80,000£	Do. do. 5 % Debs. No. 1 to 1,800 ...	100	5 %	5 %	5 %	108 —111	108 —111	...	...
1,777,000$	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	7 %	7 %	7 %	110 —115	110 —115	...	...
164,300£	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6 %	100 —105 xd	100 —105	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	4½%	4½%	5 %	9¼ — 9⅝	9¼ — 10	9⅝	...
10,277	*Chelsea Electricity Supply, Ltd., Ord., Nos. 1 to 10,277 ...	5	5 %	5 %	5 %	7⅞ — 8¼	7¼ — 8	...	...
60,000	Do. do. do. 4½ % Deb. Stock Red. ...	Stock	...	...	4½%	114 —117	114 —117	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	5 %	5 %	16 — 17	16 — 17	16¾	...
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	17½ — 18½	17½ — 18½	18½	18½
300,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	132 —136	131 —135	...	...
22,475	County of London and Brush Prov. Elec. Lightg., Ltd., Ord. 1—22,475	10	...	...	*nil*	8 — 9	8 — 9	...	...
20,000	Do. do. do. 6% Pref., 40,001—50,000 ...	10	...	...	6 %	13⅜— 14½	13⅜— 14½	...	...
10,000	Do. do. do. iss. at 2 pm., all paid ...	10	...	...	...	5½— 6½	5½— 6½	6½	5⅝
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000 ...	10	2½%	3 %	4 %	13 — 14	12½ — 13½	13⅜	13
150,000£	Do. 4½% first mortgage debenture stock	...	4½%	4½%	4½%	120 —123	120 —123	...	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	1 %	2 %	12 — 13	11½ — 12½	...	...
19,980	*St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-20,080	5	4½%	6½%	7½%	11½ — 12½	11½ — 12½	...	...
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	10 — 11	10 — 11	...	...
50,000	Do. do. 4 % Deb. stock Red. ...	Stock	...	...	...	106 —109	106 —109	...	...
67,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	4 %	5 %	7 %	11 — 12	11 — 12	...	...

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital.

§ Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME	Stock or Share. ‡	Dividends for the last three years. 1893.	1894.	1895.	Closing Quotation Sept. 16th.	Closing Quotation, Sept. 23rd.	Business done during week ended Sept. 23rd, 1896. Highest.	Lowest.
90,000	Brush Elecl. Engng. Co., Ord., 1 to 90,000...	3	5 %	2½%	...	1 — 1¼	1 — 1¼	1 3/16	1
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	6 %	3 %	...	1½ — 1⅝	1½ — 1⅝	..	...
125,000£	Do. do. 4½ % Perp. Deb. Stock.... ...	Stock	4½%	4½%	...	110 —113xd	110 —113	...	...
76,770	Do. do. 4½% 2nd Deb. Stock Red. ...	Stock	...	...	...	97 —101	97 — 101	...	...
9,104	Central London Railway, Ord. Shares	10	...	...	...	10¼ — 10⅜	10¼ — 10⅜	10⅜	...
207,649	Do. do. do. £4 paid	10	...	...	...	4⅜ — 4⅝	4⅜ — 4⅝	4½	...
630,000£	City and South London Railway	Stock	1 1/16%	1 1/16%	1 1/16%	51 — 53	49 — 51	48½	48¼
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	3 % §	*nil*	*nil*	2 — 2½	2 — 2½	...	...
89,261	Edison & Swan United Elec. Lgt., Ltd., "A" shrs, £3 pd. 1 to 89,261	5	7 %	5 %	5 %	1¾ — 2¼	1¾ — 2¼	...	...
17,139	Do. do. do. "A" Shares 01—017,139	5	7 %	5 %	5 %	3 — 4	3 — 4	...	...
100,000	Do. do. do. 4½% Deb. Stock Red. ...	Stock	...	4½%	4½%	103 —106	103 —106	...	...
110,000	Electric Construction, Ltd., 1 to 110,000	2	*nil*	*nil*	5 %	1½ — 1⅝	1½ — 1⅝	1 11/16	1 9/16
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ..	2	7 %	7 %	7 %	2½ — 3	2½ — 3	2⅝	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	*nil*	...	⅞ — 1	13/16 — ⅞	...	..
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ..	2	*nil*	*nil*	...	⅞ — ⅝	⅞ — ⅞	...	.
9,600£	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ..	10	*nil*	*nil*	10½%	10½ — 11½	10½ — 11½	..	
10,000	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	6 %	8 %	18 — 19xd	18 — 19	...	...
3,000	Do. do. do. 7% Pref.	10	7 %	7 %	7 %	18½ — 19½xd	18½ — 19½	...	...
50,000	Do. do. do. 4½ Mort. Deb. Stock	Stock	...	...	4½%	110 —115xd	110 —115	..	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	10 %	10 %	21½ — 22½	22 — 23	22¾	22
300,000	Do. do. do. 4 % 1st Mort. Debs.	100	...	...	..	107 —110	107 —110	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	1 %	1½%	2½%	13 5/16 — 13 7/16	13 7/16 — 13 9/16	...	..
10,000	† Do. do. Pref., £10 paid	10	5 %	5 %	5 %	16⅞ — 17⅜	16⅞ — 17⅜xd	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	20 %	20 %	15 %	40 — 43	40 — 43	41½	...
150,000	Do. do. do. 5 % Bonds, red. 1899	100	5 %	5 %	5 %	104 —107	104 —107	...	..
54,000£	Waterloo and City Railway, Nos. 1 to 54,000, £6 paid ...	10	..	...	...	8¼ — 8⅜	8¼ — 8⅜	8¼	...

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7½% § 1890—6%.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

*Birmingham Electric Supply Company, Ordinary of £5 (£4 paid), 6.
Electric Construction Corporation, 6 % Debentures, 103—106.
House-to-House Company (£5 paid), 4⅛—4⅜.
Do. do. 7 % Preference, of £5, 8⅜—9.
Do. do. 4½% Debentures of £100, 109—111.
Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 10—10½; 1st Preference Cumulative 6 %, £5 (fully paid), 8—8½.
London Electric Supply Corporation, £5 Ordinary, ⅞—1⅛.
Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 7½—8.

* From Birmingham Share List.

Bank rate of discount 2½ per cent. (September 10th, 1896.)

A COMPLETED CHAPTER IN THE HISTORY OF THE ATOMIC THEORY.*

(*Concluded from page* 382.)

Since these experiments have been made by different processes, by different men, under varied conditions, and since the greatest difference from the mean of the whole is only one part in a thousand, it is probable that the mean of all differs from the truth by much less than one part in a thousand. The errors of our experiments are of two kinds—accidental and systematic. If we shoot a hundred times at a mark, about half of our shots fall a little to the right and about half a little to the left. These are accidental errors; accidental errors are lessened as our manipulation improves, and they but slightly affect our final mean. Systematic errors affect all our results in the same direction. Suppose we fire a 100 shots at a target 1,000 yards distant, not examining the target till the shots are all fired. If, now, the sights of our rifle were set for 500 yards, all our shots would strike too low. This is a systematic error; systematic errors diminish as our knowledge increases.

Accidental errors can be rendered harmless by taking the mean of numerous determinations made by the same method. But systematic errors must be detected and avoided. That they have been detected and avoided in any given case can never be definitely known; it can, at best, be presumed from the fact that experiments by different methods give the same result.

As to the atomic weight of oxygen, accidental errors have now been fairly eliminated, and we can make definite numerical statements on this point. If each of the 10 sets of experiments were to be repeated, with the same skill and knowledge, there is not one chance in a 1,000 that the new mean would differ from the present mean by as much as one part in 16,000. Again, if ten new sets of experiments were to be made by new methods and new experimenters, there is not one chance in a 1,000 that the new mean would differ from the present mean by as much as one part in 2,500.

As to possible systematic errors, modesty in statement is incumbent upon all scientific men. But we have now 10 independent results in which the difference from the mean is at most only one part in 1,000. We may then fairly assume that the systematic error of the mean is less than one part in 1,000. Again, we have lately been able to take one step in advance, which throws needed light on precisely this point. It has been found possible to weigh some hydrogen, to weigh the requisite oxygen, and to weigh the water which they produce. If, now, there were some undetected systematic error in weighing either one of these three substances, occasioned, for instance, by some impurity remaining undetected in one of them, the sum of the weights of the hydrogen and oxygen would differ from the weight of the water produced. If a pound of sugar and a pound of water produce only one pound and three-quarters of syrup, there was a quarter of a pound of sand in the sugar. Now it has, I think, been proved that, if the sum of the weights of the hydrogen and the oxygen is not precisely equal to the weight of the water produced, the difference is too small to be detected, and cannot be more than one part in 25,000. If there really were a difference of this amount, and, further, if this difference were due to an error at the precise point where it would be the most mischievous, it would render the atomic weight of oxygen uncertain by one part in about 2,800.

Taking into account the presumption from the concordance of the results of different experimenters and the presumption from the agreement just mentioned, I think we are justified in assuming that the remaining systematic error is not more than one part in 1,600, and that it probably is not more than one part in 3,000.

If this is a reasonable assumption, the net results of the experiments made in Denmark, France, Great Britain and the United States is that the atomic weight of oxygen is between 15·87 and 15·89, and that probably it is between 15·875 and 15 885. By no stretch can we imagine that the truth lies in the whole number 16·00, nor in the even fraction 15·50. We cannot sanely believe it to lie in the number 15·75, having modified Prout's hypothesis into the new statement that all atomic weights are divisable, without remainder, by one *quarter* of the atomic weight of hydrogen. It will be obvious that, if we are still resolved to accept some form of the attractive illusion, we must assume that the true divisor is as small as ⅛th of the atomic weight of hydrogen, for the value 15⅞ is included within the limits given.

Then there is one small and well determined atomic weight which utterly refuses to support Prout's hypothesis or any modification yet stated by believers in the hypothesis. Further, now that the atomic weight of oxygen is well established, we can compare, with hydrogen taken as unity, the seven other small and well determined atomic weights which have been mentioned.* We see that every value differs from an integer; for lithium, nitrogen and potassium the difference is about one part in 230; for sodium, sulphur and chlorine, about one part in 180; for carbon and oxygen, about one part in 130. On the average, these values, which are the best determined in chemistry, differ from whole numbers by about one part in 180. There is less than one chance in a thousand that these numbers can possibly be so

* Address by the retiring President of the American Association for the Advancement of Science at the Buffalo Meeting. Reprinted from New York *Science*.

* The values are as follows: Li = 6·97, C = 11·91, N = 13·94, O = 15·88, Na = 22·87, S = 31·83, Cl = 35·19, K = 38·84.

much in error. These are the numbers best fitted to test Prout's hypothesis, and their evidence against it is decisive.

It ought to be added that the evidence against Prout's hypothesis seemed to many to be decisive, even without the knowledge of the atomic weight of oxygen which has recently been acquired. But the evidence can now be stated in a much more direct and simple manner; and it has gained in force, for to the seven fit instances at hand before there is added an eighth, which happens to be the most weighty of the whole.

In order to present the evidence against Prout's hypothesis when we lack an accurate knowledge of the atomic weight of oxygen, we have first to assume this value. We may, for one trial, assume that this value is the whole number 16·00, which is required by Prout's hypothesis, and see whether, on this assumption, the other seven atomic weights in question are very nearly such as the hypothesis requires.* But the average deviation from the numbers required by the hypothesis is one part in 500, and one deviation amounts to more than one part in 300. We may make another trial by assuming for oxygen, not the whole number, 16·00, but that value which shall make the sum of all the deviations the least possible; and we may also take one quarter of the atomic weight of hydrogen as our divisor.† But the average deviations from the numbers required by the theory is, even in this case, one part in 600, and the atomic weight of that element for which the determinations of friends of the hypothesis agree with those of its opponents to one part in 3,500, is supposed, after all, to be in error by one part in 500. The atomic weight of oxygen, computed expressly to give every possible advantage to the hypothesis, differs from the whole number required by the theory by one part in 250.

We read in our school books of the bed of Procrustes, to which the tyrant fitted his compulsory lodgers; if they were too short he stretched them on the rack; if they were too long he lopped off the superfluous length. This fable was really a prophetic vision; the bed is Prout's hypothesis; our friends who admire it want to stretch the most unyielding quantities, and to lop off numbers which have been determined with the greatest precision. Either the experiments are in error by an amount which seems incredible, or the hypothesis is an illusion. If the supporters of the hypothesis would avoid the conclusion they must supply better determinations, or they must detect real and tangible sources of error in those already made.

The hypothesis was most interesting and attractive; it promised, if sustained by experimental evidence, to give the means of such insight into the nature of the matter and into the intimate structure of the atoms, that it was well worth all the attention which has been given to it. That it should fail of support, that its promises could not be kept, is a matter of regret; but it is time to recognise that our hopes are quite cut off. That other elements are composed of the same substance as hydrogen may or may not be true, but we have now no hope of proving it by determinations of atomic weight. It would not be difficult, perhaps, to modify Prout's hypothesis again and again, so as to bring it into some accord with the facts. We may imagine, if we will, that the observed numbers, if determined without error, would all be divisible by the eighth part of the atomic weight of hydrogen, or the ninth, or the tenth, or by some smaller fraction. But such a hypothesis is of no interest and of no utility, because it is incapable of proof or disproof by experiment. The reason is obvious. If we suppose that all atomic weights are divisible by one tenth of the atomic weight of hydrogen, then, in case the theory is erroneous, the average deviation of the actual atomic weights from those required by the theory is only the fortieth of the unit. The man who supports a theory which has no physical basis would assert that all such ascertained deviations were due to errors of experiment. Others would reply that you cannot prove that a man is a good marksman by crowding the targets so near each other that not even his random shots can miss them all. But his backers might make so uncritical a claim.

No, Prout's hypothesis, if sub-divided far enough, may be true for all which can be proved with the balance; but in such new form it is of no use and of no interest, for it cannot be proved so as to become a safe basis for further inference. In its present form there is no root of truth in it.

So far, I have argued that Prout's hypothesis is not true as heretofore enunciated, and that, if some further modification of it is true, we cannot know it. This conclusion has been sustained by the evidence of the chemist's balance. A conclusion supported by a single kind of evidence may command the confidence of one who has been long familiar with the evidence, and who has become capable of weighing it. But for others, the concurrence of evidence of different kinds rightly adds greatly to its cogency. In this case there is such concurrent evidence. There is other proof that the atoms of some well studied elements are not *additive* structures. Let me briefly describe the nature of this evidence.

When certain elements are volatilised in a colourless gas flame, or in the electric arc, these molecules are made to vibrate, so as to produce light. By the study of this light we can, in time, learn much of the nature of the vibrating system. The observed facts are gradually reducing to order, and one result is very striking. In the case of three closely similar elements before mentioned, lithium, sodium and potassium, the complexity of vibration is precisely similar in all, and the numerical relations among the component vibrations are precisely similar in all. Therefore we are compelled to assume that the complexity of structure is the same in all, and that the relations of the component parts, and of the forces acting between them, are the same in all. To illustrate the nature of the argument: the complexity of vibration, and the numerical relations among the component vibrations in the case of a large church bell, are precisely similar to those in the case of a bell only one-third as large. Then, even without the direct evidence of other senses, we must presume that the two bells are similar structures, having similar parts similarly related. We cannot believe that the larger bell is made of a small bell loaded with weights, nor of three small bells bound closely together. The larger and the smaller are of the same order. The larger is not made of more *parts* than the smaller; it is made of more *metal*. So with the atoms of these three elements; the larger are not made up by the addition of parts which preserve their identity and remain undivided. But all we know of chemical combination relates to structures which are made by the addition of parts which preserve their identity and remain undivided. Then Prout's hypothesis assumes an analogy which does not exist, and deductions from an imaginary analogy will themselves differ from the truth, much as fairy tales differ from history.

There are still other sources of evidence drawn from the specific heats of the elements; the evidence is of the same kind, and leads to the same conclusion, but I simply allude to it.

It seems to me, then, that the exact quantitative similarity of the spectra of these elements shows that they are not compounds one of another, subject to the great chemical law of the addition of undivided parts, and that also the magnitudes of the small and well determined atomic weights differ from the values hitherto suggested by applying the law of the addition of undivided parts, and differ by five, 10 and 15 times the greatest experimental error we can reasonably assume.

So the citadel which defends the secret of the atom cannot be taken by way of Prout's hypothesis. We have carried on the assault for 80 years, and we are now satisfied that the way is blocked; we tried to breach, not a wall, but the solid mountain itself. We shall doubtless learn the structure of the atom, but we cannot learn it in the way we hoped. This chapter in our study of the nature of atoms has been fully ended.

If Prout's hypothesis cannot serve us, you will doubtless ask what other ways are open by which we may learn something of the structure of atoms. To answer is difficult; to answer adequately is impossible. Perhaps I may mention four lines in which it has been hoped by some that the desired advance could be made, and may indicate what it is reasonable to expect of each.

One of these indications of a possible source of knowledge as to the structure of atoms was suggested by certain chemical observations on some of the rare earths. My brief explanation will not do justice to the conception of the eminent chemist who investigated the phenomena. As I have said, the atom is something which, as a matter of fact, remains undivided in all chemical changes. Most atoms seem to resist every force which we can apply. But it is possible that the amount of resistance which they can offer may vary greatly; it may be that in the case of some elements the resistance is such that in some reactions the atoms remain undivided, and not in others. From the study of such cases, if there are such, we might expect much help. Now, in the case of the common and well studied elements, the occurrence of such cases has not been suspected; but some of the rarer elements, examined by a process which is frightfully laborious, have exhibited phenomena which suggest, as a hypothesis to be further studied, such a sub-division of atoms. But it is probable that we have mixtures of distinct elements which we do not yet know how to separate from each other by simple analytical processes. This chapter, we may fairly presume, will be valuable; but not because it will tell us anything new about the structure of atoms.

Certain spectroscopic phenomena have suggested that some elements may be decomposed by the action of a high temperature. For instance, it has been thought not impossible that, at the temperature of the electric arc, potassium compounds quite free from sodium should begin to show the spectrum of sodium, because at this temperature potassium is decomposed so as to produce sodium. This hypothesis has been carefully investigated; in part, by the accomplished physicist who is its author; in part, at his suggestion and invitation. It is found that, if years are given to the preparation of potassium compounds free from every trace of sodium, then it is impossible to obtain from them any phenomena suggesting a decomposition into sodium. Here, again, the new chapter, as far as it relates to the structure of the atom, is likely to be but short.

A third suggestion did not rest upon any observed chemical phenomena, but was a purely intellectual creation. This is the hypothesis that atoms are vortex rings in a frictionless fluid. It belongs to the mathematical physicists, rather than to the chemist, to discuss this interesting suggestion. It may be said that it has seemed not impossible that the chemist should find a vortex ring capable of exerting certain chemical forces. But the fate of the hypothesis rested, not with the chemist, but with the mathematical physicist; and it has been found that the theory demands that the weight of a body composed of vortex atoms should increase with rise of temperature. It is scarcely possible that this can be the fact; if, then, the mathematical and physical reasoning involved is sound, it is scarcely possible that atoms consist of vortex rings. The probability, is, therefore, but small that we are to learn of the nature of atoms by means of this hypothesis.

Some spectroscopic and other optical phenomena seem to promise more light as to the structure of molecules and atoms, though the dawn is not yet. Thanks to the concave grating, we can determine the frequency of vibration of the light from any source with great accuracy. When the light is complex we can determine, with great accuracy, the relative frequency of the component vibrations. In the cases which have been best studied, the observed frequencies have been reduced to rather simple numerical relations. From the study of these relations we may expect, in time, to determine the structure of the vibrating systems. But the way is long and difficult. Let us illustrate the nature of the method by means of a familiar example,

* The values on this assumption are as follows:—Li = 7·02, C = 12·00, N = 14·04, O = 16·00 (assumed), Na = 23·07, S = 32·04, Cl = 35·46, K = 39·14.

† The values are as follows: Li = 7·00, C = 11·96, N = 13·99, O = 15·94, Na = 22·96, S = 31·96, Cl = 35·33, K = 39·00.

namely, by the study of the structure of a sonorous vibrating system by means of the study of the sonorous vibrations produced by it.

Let us suppose a person deprived of the sense of hearing, but master of the whole mathematical theory of sound. Suppose, further, that he has an instrument which will do for sound what the spectroscope will do for light. With this instrument, let him observe the frequency and the relative intensity of the vibrations produced by certain musical instruments which we cause to vibrate for him, but withhold from his inspection. Let us, first, sound for him a single note on a piano. The vibrations produced are, as you know, somewhat complicated. Our imagined experimenter, with his instrument, observes vibrations whose frequencies are 100, 200, 300, 400, 500 and 600 in one second; and he also observes that the vibrations of 100 and 500 are of nearly equal intensity, that the vibrations 200, 300 and 400 have more than twice as great an intensity, and that vibration 700 is very feeble. From these facts, if his attainments are sufficient and his imagination sufficiently fertile, he can determine what system produced the sound. He imagines every possible vibrating system—drum, cymbals, trumpet, flute, organ-pipe, harmonium-reed, violin-string, piano, harp and more. Next, assuming each imagined system of such size or tune as to produce one hundred vibrations a second for its gravest tone, he computes what other vibrations will be produced and what the intensity of each. He finds, for instance, that a closed organ-pipe will give only the frequencies 100, 300, 500, but will not produce the other observed frequencies 200, 400, 600. Therefore, he concludes the sound we produced for his study is not due to a closed organ pipe. He finds, after many trials, that the observed frequencies and intensities could be produced by striking a stretched cord with a soft hammer, at a definite point near the end of the cord, so quickly that the cord and hammer remain in contact about the sixth-hundredth part of a second, and that the observed phenomena could not be produced by any other of the imagined vibrating systems. Then he concludes that the observed sound was probably produced by the stretched cord of a piano. He will have detected the true system, by first imagining every possible system, by computing the frequencies and corresponding intensities due to each hypothetical system, and by then comparing computation and observation.

For a second example, suppose we ring, for our imagined observer, a bell of a certain form, and that he notes the frequencies 200, 475, 845 and 1,295 in one second; in which, also, he finds that the vibration 845 so predominates as to give its pitch to the compound tone. Our observer will not be able to refer this sound to any stretched cord, or to any organ pipe or other wind instrument; for all these are limited to frequencies contained in the series 200, 400, 600, 800. A uniform metallic bar, suspended and struck like the triangle of an orchestra, will give frequencies not contained in this list, but they will be 200, 550, 1,080, and 2,670, instead of 200, 475, 845 and 1,295. But if our observer has adequate powers, he will imagine a hemispherical bowl of suitable dimensions, and will, in imagination, add rigidity in suitable places, until, in time, he will have devised a system whose computed vibrations agree in frequency, and in distribution of energy, with those of the invisible sounding body. Then he would conclude that the observed sound was due to a bell of the form assumed in the successful computation.

This illustration sketches, imperfectly, I fear, the laborious method by which we may learn the structure of a vibrating system from a study of the vibrations produced by it. When we attempt to use this method in order to learn something about the structure of molecules and atoms, our powers of imagination and our mathematical skill are none too much. We know but little which can suggest plausible hypotheses. The facts which are to be explained have been but recently reduced to order. Accordingly, little has been actually accomplished. But there are some few examples of the use of this method of studying the structure of molecules and atoms.

In one such example the structure imagined consisted of a system of concentric spherical shells, each connected with the adjacent shells by springs. This complicated structure admits of relatively simple computation, and was taken because it fairly well represents a rather simple imagined structure, for which, however, computation is difficult. But it was found that the results computed on this hypothesis gave little promise of agreement with facts.

This was a dynamical hypothesis; it suggested not only vibrations, but the forces which were to produce them. A second example suggests certain possible motions, but not the forces which might produce the hypothetical motions; it is not dynamic, but kinetic.

As we know, many of the lines in the spectra of the elements are double. For instance, when a volatile compound of sodium is brought into a colourless gas flame, this is coloured yellow. When we examine this yellow flame with a spectroscope of sufficient power, we see that there are two frequencies, differing from each other by only one part in 1,000. Now, it is probable that these two frequencies are due to the vibrations of one and the same body. There are many illustrations of the fact that a given body may perform two different vibrations whose frequencies differ but slightly. For instance, if we suspend a ball by means of a cord and let it oscillate as a pendulum, it is well known that a swing of 6 feet takes a little more time than a swing of 3 feet. Suppose, then, that we let our ball swing 6 feet north and south, and also 3 feet east and west at the same time; the two motions may be combined so that the ball moves in an ellipse—an ellipse whose longer axis is north and south. If the longer and the shorter swing had precisely the same frequency, the axis of the ellipse would continue in this direction; but since the frequencies differ, the ellipse slowly revolves. Conversely, from the revolution of an ellipse, we should infer a difference of frequency in the two component vibrations. So it is suggested that the two slightly different frequencies in the light sent out by ignited sodium are due to an elliptic motion in the molecule in which the elliptic orb slowly revolves; this suggestion has not yet been carried so far as to specify any hypothetical cause for the revolution of the ellipse.

These two examples, both due to eminent English physicists, may serve to illustrate the method by which, if I am not mistaken, we are not unlikely to learn much as to the structure of molecules and atoms. We must not expect rapid progress. Even comparatively simple hypotheses may require, for their due examination, the invention of new mathematical methods. And useful hypotheses are rare: like the finding of buried treasures, they are not to be counted on. But, since Prout's hypothesis has rendered us its final service, new hypotheses must be devised, competent to guide us further on our way. Let us hope that, before this city again honours our Association with its invitation to meet here, American chemists and physicists may have had some honourable share in such new advance.

Edward W. Morley.

Cleveland, O.

HOW TO SAVE MONEY ON FEEDERS.*

By J. E. WOODBRIDGE.

Many electric roads are making such extensive suburban changes or consolidations or other additions to their distant load, that they are finding themselves confronted with a serious problem of long distance power transmission.

The building of small power stations to supply these outrunners of an electric system is objectionable, as they are very uneconomical to run in comparison with large central stations. On the other hand, the cost of feeders for roads extending from 6 to 12 miles from the station becomes almost prohibitive. This difficulty is particularly problematical where the load on the line extensions is intermittent, generally light, but occasionally very heavy. Such is the case with lines leading to summer resorts, fair grounds, race tracks, and the like. An extra station to supply such a demand is out of the question, and miles of thick feeders for use one day in the week in the summer months are extravagant investments. In cases of this kind, the modification described below of the rotary transformer system is a great help in producing a uniformly distributed voltage. Many roads have on hand small generators ranging from 30 to 100 kilowatts, which have been replaced by larger direct connected units. With these and a few switches the system can be equipped. Fig. 1 shows diagrammatically the general arrangement of the machines, C, C, C, representing the ordinary power station generators, one of which, C, is equipped with a double throw main switch.

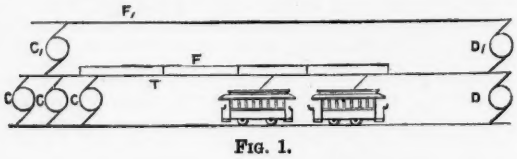


Fig. 1.

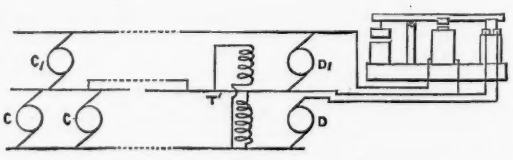


Fig. 2.

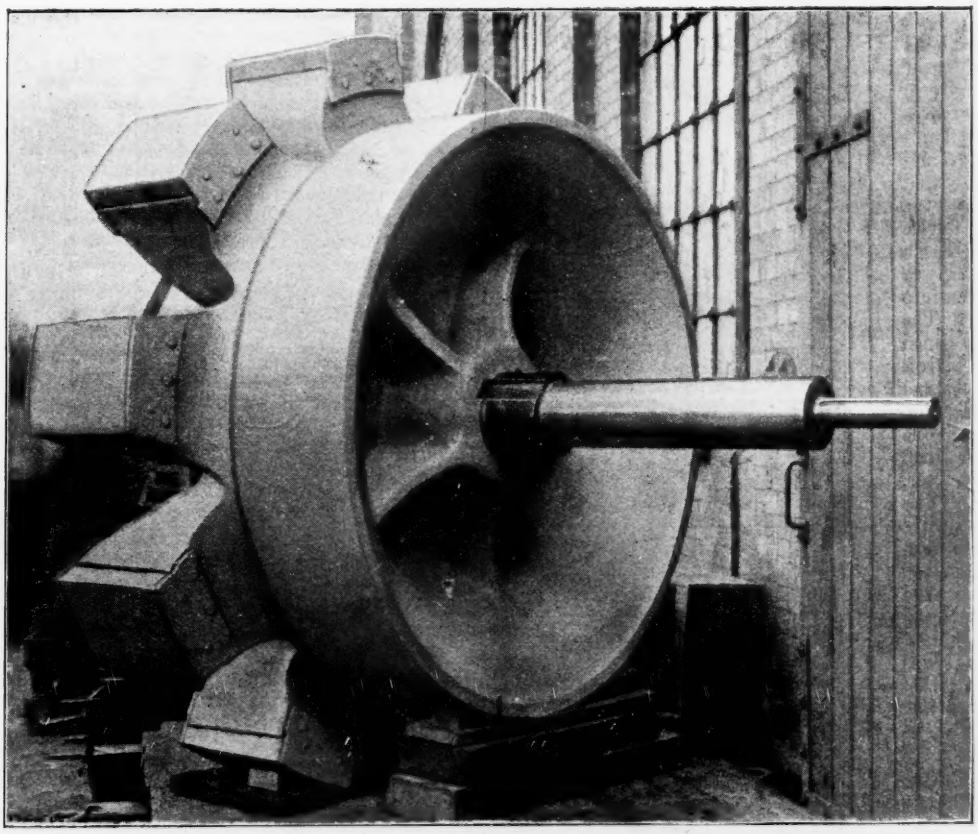
In the down position this switch connects C_1 in multiple with the other dynamos as usual, and in the up position connects C_1 in series with the other dynamos, as shown. T represents the trolley wire, F the ordinary feeders, and F_1 a feeder insulated from the others. D and D_1 represent two small generators bolted or coupled to each other, preferably coupled, and situated at any desirable centre of distribution for the distant end of the road. D and D_1 are connected in series as shown, with the trolley wire at their common terminal. F_1 and the ground return will then constitute a 1,000-volt circuit. D_1 will act as a motor, and D as a dynamo. The capacity of this circuit will be the combined capacity of D and D_1; that is, if they are each 100-kw. generators, they will deliver 200 kilowatts to the trolley wire. This apparent paradox is due to the fact that the current coming *viâ* F_1 down through D_1, and the car motors to ground, generates an

* *Electrical World.*

equal amount up from the ground through D to trolley, so that both machines feed the trolley wire, though one is a motor and the other a generator.

The great advantage of this is, that the loss in the feeder, F, is reduced 75 per cent. If the load is increased it will carry double the load it would carry at 500 volts, with one-half the fall in trolley voltage, or quadruple with the same fall in voltage.

What is generally more important is the fact that it reduces the loss in the ground return in the same proportion. If what is desired is extension of the lines, this system will allow double the length of circuit with the same cost of feeders, or quadruple the length with the same size feeders, the present length at 550 volts considered as a basis.



The Brush Company's New Alternator.—Fig. 2.

Of course, two or more of the station dynamos may be connected with double-pole switches, to feed as desired either the 500-volt or 1,000-volt bus bars. Also, any number of distant extensions may be fed at 1,000 volts by installing in the car sheds or other convenient location a pair of coupled machines, connecting them to the 1,000-volt feeders. In a majority of cases the load is sufficiently light a large part of the time to render the feeders ample to carry it at 500 volts. At all such times D and D_1 may be shut down, F_1 connected to the trolley and a 500-volt bus bar, C_1 being used in the usual manner, to provide for the running of these motor generators without attendance and for their proper control when the circuit-breakers go out. The arrangement shown in fig. 2 may be used. Here the fields D and D_1 are both fed from trolley to ground. An electro-magnetic switch of type used to cut out storage cell when charging. It consists of a powerful magnet with a pivoted armature carrying an inverted U-shaped copper rod, which dips into two cups when the magnet is excited. This switch is designed to open the circuit at the point shown, and its magnet, wound for 500 volts, is in shunt with D_1. Its armature should be counterweighted, so that when against the back stop it will only be attracted when D_1 is given a voltage of 450 volts or more. If now a short circuit occurs on the line, and all the circuit-breakers open, the voltage of C_1 should first be turned down, and the circuit breakers then restored. This will excite the fields of D and D_1. C_1 should then be turned up rapidly, which will start D and D_1, and when they approach voltage, switch S, which fell open when the line was dead, will close automatically and restore normal working.

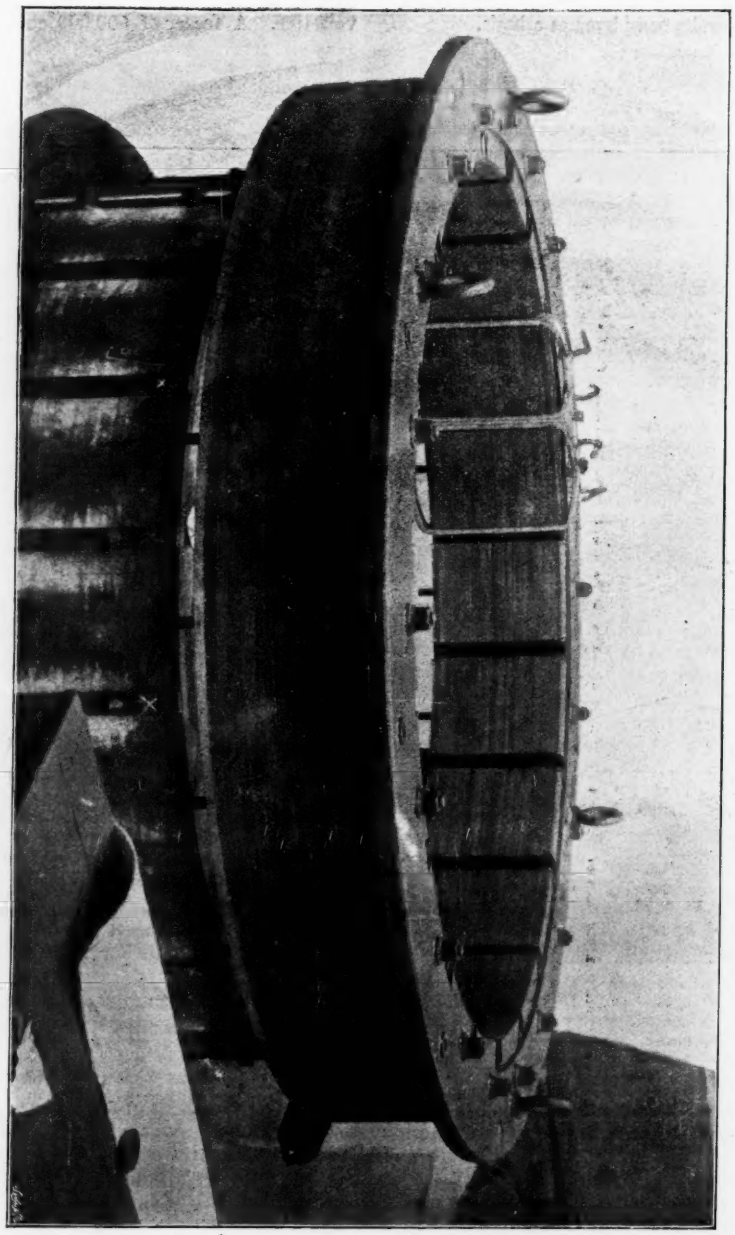
With this arrangement also the motor generators may be started or stopped at any time from the central station, simply by starting or stopping the dynamo, C_1, feeding the 1,000 volt line. A feeder of 500,000 circular mils cross-section, 5 miles long, with its ground return, will have a resistance of at least 1 ohm. Such a line will give the cars 100 amperes at 450 volts, with a generator voltage of 550. With the system here described, using two 100-kw. machines at the centre of distribution, and the same generator at the station, 400 amperes will be fed to the trolley wire at the same voltage, and with the same proportional loss of energy. In short, an increase of feeder capacity of 300 per cent. is obtained by an increase in dynamos of 100 per cent.

THE BRUSH COMPANY'S NEW ALTERNATOR.

We illustrate this week a new form of alternator which is being brought out by the Brush Electrical Engineering Company especially for low period work, whether ordinary or

multiphase, and to meet the requirements of those who prefer the iron-cored type of alternating current dynamo. The new alternator possesses features of considerable interest. It is an inductor machine; that is to say, it belongs to the class of alternators distinguished by having the conductors fixed, both of the armature and of the exciting circuit, the E.M.F. being produced by a variation of the magnetic flux brought about by the movement of a portion of the iron of the magnetic circuit. This principle when applied, as it is in this instance, results in a machine having very great simplicity and reliability.

The torque is exerted only on the mechanically strong iron portions, and not at all on the windings. The armature coils are simply rectangles of well insulated copper wire or strip, placed in slots or grooves in the fixed laminated iron structure, and secured therein by the simplest device imaginable, a wooden strip or wedge driven into each slot. The slots are lined with a thick U-section channel piece of micanite, or other suitable insulator, in which the coils repose, thus a very efficient double insulation is provided between iron and copper. And it should be noted as a point of great practical importance that this construction allows of practically any required space being given to insulation (seeing that the conductor is not placed in the gap), while all necessity for laminating the copper is avoided, the only losses in the copper being those due to its resistance to the current.



The Brush Company's New Alternator.—Fig. 1.

The arrangement of the machine is clearly shown in the illustrations. It will be observed that the feature of a single annular field winding, so long known in connection with the ordinary Mordey-Victoria alternator, is adhered to; but that this winding is now fixed in position on the stationary part of the machine.

This machine realises, mechanically and electrically, the desire often expressed with regard to dynamos, that the *unmechanical materials should have no mechanical work to do*. The machine resembles a transformer, inasmuch as its coils lie in their places without motion, and with no strain on them. It will be within the knowledge of many of our readers that this type of inductor alternator has come into considerable use on the Continent, being made in one form or another by most of the large electrical engineering manufacturers. It is thus not an untried type that the Brush Company is introducing, and its position in years past as a Continental manufacturing firm has enabled it to avail itself directly of this experience, and to embody in the design those details which have resulted from experience.

The machine is made either with a double ring of armature coils and a double set of laminated polar projections, or with only a single ring as in fig. 1.

The armature ring is built up of laminated iron, bolted together ready to be placed in position in the solid iron foundation. The slots for the reception of the coils are clearly seen in this view, and one or two coils placed in position.

Fig. 2 shows the inductor or rotating portion of this machine. It is constructed of cast-steel, with laminated polar faces. The small circular part forms an idle pole, the flux being merely transmitted through a continuous air gap, to complete the magnetic circuit.

In the inductor for the double ring form the smooth surface is replaced by a notched laminated surface, facing the second ring of covered coils. But the principle remains the same.

This alternator was patented several years ago by Mr. Mordey, and was illustrated in one of the editions of Prof. S. P. Thompson's dynamo book, and elsewhere, and it may be added that in a recent interference case the Comptroller of the Patent Office gave a very strong decision in favour of Mr. Mordey's patent, of which the Brush Company are proprietors. We learn that one of the largest Continental firms has taken a license under this patent. We understand that this machine is not intended to displace the Brush Company's Standard alternator, which is giving every satisfaction, the improvements introduced some two or three years ago by ensuring coolness of working and ability to stand short-circuiting, having won for the machine the highest praise from central station engineers. The two types will be put on the market side by side, and in the opinion of the company, represent the best designs of their respective forms—the coreless and the iron-cored.

X RADIATION AT THE BRITISH ASSOCIATION.

The President's address, and the papers and discussions on Friday and Saturday in Section A were chiefly devoted to a variety of different kinds of radiation of which the nature is not yet fully understood. Besides the Röntgen X rays, the scientists find that they must now admit many other kinds of radiation into the category of the unknown. In this category we must now include at least cathode rays, Lenard rays, Röntgen rays, Becquerel rays, and Wiedemann rays.

Professor J. J. Thomson's presidential address was mainly a repetition of his Rede lecture, with the exception of a reference to some very interesting experiments which he has recently carried out along with Mr. E. Rutherford, and which formed the subject of a paper which was read before the section on Friday. Professor Thomson started by saying that as yet no crucial experiment had been discovered which would prove that the Röntgen rays were transverse vibrations like ordinary light. Recent mathematical investigations by Helmholtz had shown that it was possible to have transverse waves possessing all the properties of the Röntgen rays. The deflectable Lenard rays, outside the tube, he thought must be electric currents in the air, which would be temporarily made conducting by the passage of Röntgen rays. Though the window in the Lenard tube was connected to earth, he considered that this would not make it a complete shield for the electrostatic effects of a rapid bombardment of electrified particles inside the tube. Hence a potential gradient would be created outside the aluminium window, and give rise to currents in the Röntgenised air. This theory, however, was made to appear highly improbable by the subsequent statement of Lenard, that he had made absolutely certain that there were no Röntgen rays present in his experiments.

Lenard, who was one of the lions of Section A, was distinguished no less by the thorough grasp which he appeared to have of the whole field covered by his experiments, than by the clearness and modesty with which he expressed his views. He wished it to be understood that the Röntgen rays had not been present in his experiments, as has often been asserted. Only on one occasion had he obtained a slight indication of rays that were not deflected by the magnetic field. In his experiments, the vacuum was not sufficiently high to produce Röntgen rays. He found that the amount of deflection of the Lenard rays outside the tube, and of the cathode rays inside, was the same for a given strength of magnetic field. The amount of this deflection varied with the vacuum in the tube where the rays were generated, but was not affected by variations in the pressure of the gas into which the rays passed after passing through the aluminium window. He assumes, therefore, that the deflection of the Lenard rays would be the same in air at ordinary pressure as in a vacuum; though this deflection cannot be measured in the former case, on account of the great dispersion.

Lenard's view of the relation of the Röntgen rays to the cathode rays is extremely simple. They are, he considers, cathode rays, which differ from other cathode rays in no other respect except that they cannot be perceptibly deflected by the magnetic field. This distinctive property he considers to be due to the fact that they are emitted from the cathode in a higher vacuum than the deflectable rays. Lenard considers that rays of all degrees of deflectability can be produced from the most deflectible cathode rays to the non-deflectible Röntgen rays. Lenard, of course, does not consider that the cathode rays are a stream of electrified particles, but adopts the German theory that they are a process of some kind in the ether.

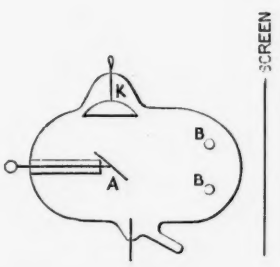
Some interesting experiments were described by Professor S. P. Thompson which have an important bearing on the relation between the cathode and the Röntgen rays. He has constructed a kind of focus tube which is shown in fig. 1, in which K is a concave cathode disc, and A is a platinum anticathode fixed at an angle of 45°. Two aluminium wires, B, B, are fixed across the tube, and connected to the outside by short platinum wire connections, so that they can be electrified by a positive or negative electrostatic charge when required. At a moderately high vacuum, as is well known, a visible cone of cathode rays is projected from the disc K on to the plate A. With a higher vacuum this cone becomes invisible. Professor Thompson has observed an important difference in the properties of the rays in these two cases.

When the low pressure visible cone is produced in the tube it is regularly reflected by the plate A, and casts the ordinary cathode shadows of the wires B, B on the glass wall of the tube. Now, he finds that these shadows can be deflected by a magnetic field; that is to say, they are displaced from their normal position on the glass wall of the tube when a magnetic field is applied. Another curious property of these shadows is observed when the wires, B, B, are electrified. When the wires are positively electrified, the shadows contract; when they are negatively electrified, the shadows expand and spread out. No shadows are produced by the low pressure rays on a phosphorescent screen placed outside the tube.

The behaviour of the high pressure invisible rays is found to be quite different. The shadows of the aluminium wires are now thrown upon the phosphorescent screen and not upon the glass wall of the tube; they can no longer be deflected by a magnet; and the positive or negative electrification of the aluminium wires have not the slightest effect upon the breadth of the shadows of the wires.

Prof. Thompson described several more interesting experiments that he had made on this subject of the relation between the cathode and the Röntgen rays, which we expect to be able to describe at greater length at a future date.

The paper read by Prof. J. J. Thomson and Mr. E. Rutherford on "The Laws of Conduction of Electricity through Gases exposed to the Röntgen Rays," is a very



important contribution to molecular physics. The previous experiments of Prof. Thomson and others have shown that insulating gases become conductors of electricity when exposed to the Röntgen rays. Air which had been thus exposed to the Röntgen rays was blown through a red hot tube without losing its newly acquired conducting properties. It was also blown through filters of wire gauze, such as had been used in Lord Kelvin's experiments, without producing any change. On the other hand, when blown through filters of fine glass wool, or bubbled through water, it lost its conductivity. But the most important discovery made by the authors of the paper was the effect of a current of electricity upon the conducting properties of Röntgenised gases. Even with small currents the conductivity was considerably reduced, and with moderately large currents it entirely disappeared. The experiments showed that the Röntgenised air behaved towards the electric current like a very dilute solution of an electrolyte. In the dilute solution of an electrolyte, the molecules of the electrolyte are supposed to be dissociated into ions by the action of the solvent, and the amount of current which passes through the electrolyte depends on the number of these dissociated ions in the path of the current. A curious result which follows from this law is that with very high E.M.Fs. a thick layer of the electrolyte, or Röntgenised gas, has less resistance than a thin layer. This result was verified by experiment in the case of the gas, and thus afforded an important confirmation of Prof. Thomson's theory. Prof. Ayrton pointed out an interesting analogy between these experiments and the behaviour of the electric arc. It has long been known that the resistance of the electric arc, within certain limits, decreases as its length increases. This points to the presence in the arc of an electrolytic process.

Sir George Stokes made some remarks in Section A on his latest theory of the Röntgen rays. The absence of any reliable evidence of the diffraction of the Röntgen rays has induced him to abandon the transverse wave theory. He will not, however, accept Lenard's theory that the Röntgen rays differ from the cathode rays only in degree. He adopts the theory that the cathode rays are a stream of flying particles. The bombardment of the anticathode by the cathode rays produces a rapid series of non-periodic disturbances, which are propagated from it in every direction. Sir George Stokes has satisfied himself, by mathematical investigation, that such non-periodic disturbance would not exhibit diffraction phenomena. The theory of diffraction shows that a succession of timed periodic impulses is necessary for the production of diffraction phenomena. He explains the production and propagation of Lenard rays in a vacuum, by the analogy of a copper plate placed in a solution of sulphate of copper, through which a current is passing. As is well known, the copper molecules appear in this case to pass through the copper plate, but the explanation in terms of Grotthuss' theory is simple and well known. Sir George Stokes also applied his theory of non-periodic disturbances to the Becquerel rays. If periodic impulses are applied to one end of a suspended chain, they will be transmitted down the chain as transverse waves till they reach the free end, where they will produce sudden non-periodic jerks. This chain represents the molecule of a uranium salt or other substance capable of producing Becquerel rays. The periodic vibrations of ordinary light impinge on the molecules and produce periodic vibrations which become non-periodic disturbances at the free ends of the molecules. Röntgen rays may also, he thinks, be produced, according to this theory, from a paraffin lamp, and for this conclusion there is some experimental evidence. The combination of the carbon and oxygen atoms in the flame of the lamp is probably non-periodic, and the necessary condition for the production of Röntgen rays is therefore present. As far as Stokes's theory is concerned, it is a matter of indifference whether the non-periodic disturbances are longitudinal or transverse.

Prof. S. P. Thompson described some interesting experiments on what he calls hyperphosphorescence—a word which will compare favourably in length with some of the names built up in Germany. It appears that Prof. Thompson has been working simultaneously with Becquerel on the properties of certain kinds of fluorescent light. Becquerel and Thompson have found that the rays from uranium salts and other fluorescent bodies have the property of affecting photographic plates through opaque screens. Prof. Thompson discovered that metallic uranium which had been exposed to sunlight fogged a photographic plate through an aluminium case. Applying to the Röntgen rays the theory that the best absorbers should be the best transmitters, and taking into consideration the fact that the absorptive power of bodies for Röntgen rays is nearly proportional to their atomic weights, Prof. Thompson concluded that metallic uranium must be superior even to platinum as a reflector or emitter of the X rays. He constructed an experimental tube which completely justified this conclusion. One-half the platinum reflector of an ordinary focus tube was coated with uranium, and when the tube was excited the superior brilliancy of the rays emitted from the uranium could be readily perceived.

Prof. Thompson had also found that the light from phosphorus could affect the photographic plate through an opaque paper screen, but could not pass through aluminium; and he exhibited a table showing how the many recently discovered kinds of radiation differed from each other in their penetrating power, magnetic deflectibility, and other properties, all which only tended to make the confusion of the theories on this subject worse confounded.

In the discussion on Prof. Thompson's paper, Dr. Dawson Turner mentioned some experiments he had made with the glow-worm. It appears that the glow-worm has been emiting X rays since it began to glow. It leaves a photographic trail on a sensitive plate, from which it is separated by an opaque screen. It is even found to emit these X rays when its glow is not visible to the eye. Prof. Thompson suggested that X rays may be the ordinary means of optical communication among glow-worms, and that, for that reason, Providence has not found it necessary to furnish the insect eye with a lens.

NEW PATENTS.

[*Compiled expressly for this journal by* W. P. Thompson & Co., *Electrical Patent Agents, 322, High Holborn, London, W.C., to whom all inquiries should be addressed*]

NEW PATENTS.—1896.

19,729. "Improvements in electric traction." C. H. Gadsby. Dated September 7th.

19,757. "Improvements relating to the connection of constant current dynamos to electric lamp circuits." W. R. Lake. (C. N. Black, United States). Dated September 7th. (*Complete*)

19,767. "Improved methods of and means for controlling electric motors." R. Belfield. (The Westinghouse Electric and Manufacturing Company, United States.) Dated September 7th.

19,783. "Improvements in electric arc lamps." H. Nunns. Dated September 8th.

19,818. "Improvements in electric heaters." J. E. Meek and H. W. Johns Manufacturing Company. Dated September 8th. (*Complete*)

19,821. "Improvements in and relating to reflectors for electric arc, incandescent, and other kinds of lamps." F. J. Warden-Stevens. Dated September 8th.

19,822. "Improvements in automatic circuit-breakers." The British Thomson-Houston Company, Ltd. (E. M. Hewlett, United States) Dated September 8th. (*Complete.*)

19,870. "Improvements in dynamo-electric machines and electric motors." S. A. Nash. Dated September 8th.

19,871. "Improvements in or connected with electric automatic regulating or controlling apparatus." A. B. Blackburn and W. L. Spence. Dated September 8th.

19,877. "Improvements in connecting the plates or elements of voltaic cells and batteries." D. G. Fitzgerald. Dated September 8th.

19,894. "An improved method of manufacturing permanent magnets." F. L. Wilder. Dated September 9th.

19,908. "Improvements in reflectors for incandescent electric lamps." F. G. Thomas. Dated September 9th.

19,911. "An apparatus for determining or ascertaining the velocity of air currents in coal mines and other situations, and for other purposes by novel electrical and other means." J. Thompson. Dated September 9th.

20,035. "Improvements in electrical batteries." D. Mathieu. Dated September 10th.

20,061. "Improvements in the manufacture of filaments for electric lamps." J. A. Sinclair. Dated September 10th.

20,062. "Improvements in the manufacture of filaments for electric lamps." J. A. Sinclair. Dated September 10th.

20,077. "Improvements in and relating to primary batteries." T. F. Boland, C. J. Hubbell, and H. C. Hubbell. Dated September 10th. (*Complete.*)

20,079. "Means for enabling the current from an alternating dynamo to be utilised for charging secondary voltaic batteries, and for other purposes." E B. Wright. Dated September 10th.

20,086. "A new or improved armature for dynamo-electric machines." G. Offermann. Dated September 10th. (*Complete.*)

20,095. "An improved controlling and reversing switch for electric motors and similar uses." F. H. Royce and E. A. Claremont. Dated September 11th. (*Complete.*)

20,106. "Improvements in secondary batteries." S. A. Rosenthal. (S. J. von Romocki, Germany.) Dated September 11th.

20,121. "Improvements in overhead conductors for electric traction." J. M. M. Munro. Dated September 11th.

20,135. "Improvements relating to writing pads for recording telephonic communications and for like purposes." A. Simmons. Dated September 11th.

20,217. "Improvements in electrical switches." J. H. Tucker. Dated September 12th.

20,242. "Improvements in appliances for rendering astatic galvanometer needles independent of disturbances by earth magnetism. Siemens Bros. & Co., Ltd. (Siemens & Halske, Germany.) Dated September 12th.

20,243. Improvements in appliances for protecting electrical measuring instruments from external influences. Siemens Bros. & Co., Ltd. (Siemens & Halske, Germany.) Dated September 12th.